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Utah Water Research Lab.
Logan

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Intermittent Sand Filter Systems

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WASTEWATER STABILIZATION LAGOON--INTERMITTENT SAND FILTER SYSTEMS

by

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FOREWORD

The Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. The complexity of the environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment, and management of wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, for the preservation and treatment of public drinking and community sources, for the preservation and treatment of public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic effects of pollution. This publication is one of the products of that research; a most vital communications link between the researcher and the user community.

As part of these activities, this report was prepared to make available to the sanitary engineering community the results of field tests of existing lagoon-intermittent sand filter systems designed for the removal of algae, bacteria, and chemical components from lagoon effluent.

Francis T. Mayo, Director
Municipal Environmental Research Laboratory

ABSTRACT

Intermittent sand filtration has been demonstrated on a laboratory and pilot scale to be a technical and economical method for upgrading wastewater lagoon effluent to satisfy stringent discharge standards. However, very little intermittent sand filtration full scale performance information is available. This study evaluated the performance of three prototype lagoon-intermittent sand filtration systems for three 30 consecutive day periods during different seasons throughout a sixteen month period. The systems were located at Mt. Shasta, California; Moriarty, New Mexico; and Ailey, Georgia. Twenty-four different parameters were monitored on 24-hour composite samples. In addition, information concerning design criteria employed, operation and maintenance procedures, and costs was collected and evaluated for each system.

The results of the study indicated that, although operation and maintenance requirements are relatively small, overall lagoon-intermittent sand filtration performance is affected by operator skill and experience. Actual manpower requirements at the three sites ranged from 0.14 to 2.0 man-years and were related to the size and complexity of the individual system. The mean lagoon influent, lagoon effluent, intermittent sand filter effluent, and chlorinated effluent biochemical oxygen demand (BOD_5), suspended solids, geometric mean fecal coliform concentrations, and pH value ranges by tour for each facility are summarized below.

The 1972 Federal Secondary Treatment Discharge Standards were satisfied by all three systems with the exception that 85 percent removal of the influent suspended solids concentration was not accomplished during two of the nine sampling periods. It was determined that the intermittent sand filters were necessary for each system to satisfy the required discharge standards.

Annual capital costs for the three systems ranged from \$0.02 to \$0.05 per cubic meter of filtrate while annual operating costs ranged from <\$0.01 to \$0.02 per cubic meter of filtrate. Design and cost data for 13 additional lagoon-intermittent sand filtration systems is also presented. The results clearly indicate that intermittent sand filtration is a viable low cost method for upgrading wastewater lagoon effluent.

The results of the study were used to develop design criteria for an intermittent sand filter system. In addition, these criteria were employed to design a typical intermittent sand filter.

This report was submitted in fulfillment of Grant Number R804592 by Utah State University under the sponsorship of the U.S. Environmental Protection Agency. This report covers a period from October 23, 1976, to May 22, 1979, and work was completed as of July 15, 1979.

SUMMARY OF PERFORMANCE OF LAGOON-INTERMITTENT SAND FILTER SYSTEMS

Location and Parameter	Tour #	Lagoon Influent mg/ℓ	Lagoon Effluent mg/ℓ	Filter Effluent mg/ℓ	Chlorination Effluent mg/ℓ	Removal %
Mt. Shasta, California						
BOD_5	1	110	26	21	14	87
	2	121	19	4	3	98
	3	110	20	7	4	96
SS	1	85	37	26	21	75
	2	86	69	13	13	85
	3	73	33	11	11	85
FC[a]	1	0.65×10^6	720	53	<1	99.99
	2	3.38×10^6	20	2	1	99.99
	3	0.37×10^6	179	37	5	99.99
pH[b]	1	6.7-7.6	7.4-9.0	6.0-7.0	5.7-7.0	-
	2	6.5-7.0	8.7-9.7	6.7-7.7	6.4-7.3	-
	3	6.8-7.0	7.5-9.3	6.6-7.5	6.3-7.3	-
Moriarty, N.M.						
BOD_5	1	133	35	37	20	85
	2	135	22	24	10	93
	3	177	32	38	21	88
SS	1	174	83	68	23	87
	2	128	89	91	15	88
	3	155	71	72	8	95
FC[a]	1	3.97×10^6	27	2	8	99.99
	2	6.70×10^6	782	51	91	99.99
	3	2.03×10^6	62	1	2	99.99
pH[b]	1	7.7-8.2	8.5-9.4	8.3-9.3	7.5-8.5	-
	2	7.9-8.2	8.7-9.1	8.5-9.1	7.9-8.3	-
	3	7.9-8.5	8.1-9.2	8.7-9.2	7.7-8.2	-
Ailey, Georgia						
BOD_5	1	63	11	4	3	95
	2	76	20	5	4	95
	3	63	34	14	10	84
SS	1	116	31	14	13	89
	2	148	48	11	8	95
	3	65	49	19	17	74
FC[a]	1	0.58×10^6	8	3	1	99.99
	2	5.19×10^6	9	1	<1	99.99
	3	0.75×10^6	149	21	<1	99.99
pH[b]	1	6.9-7.6	7.6-10.1	6.5-7.1	6.3-6.8	-
	2	7.3-7.8	9.1-9.9	6.4-7.6	7.0-7.4	-
	3	6.5-7.7	7.7-9.3	6.6-7.7	6.5-7.2	-

[a] Expressed in number of organisms per 100 mℓ.

[b] Expressed in pH units.

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LIST OF ABBREVIATIONS

Alk. = Alkalinity
BOD_5 = Five Day Biochemical Oxygen Demand
BOD_5 w/N.I. = Five Day Biochemical Oxygen Demand with Nitrification Inhibitor
C^o = Degrees Celsius
CA. = California
cells/ml = Algae Cells Per Milliliter
cm = Centimeter
COD = Chemical Oxygen Demand
$\$/m^3$ = Dollars Per Cubic Meter of Water
e.s. = Effective Size
F.C. = Fecal Coliform Bacteria
ft = Feet
GA. = Georgia
ha. = Hectare
hr. = Hour
i.e. = *id est*
in. = Inch
I-DO = In situ Dissolved Oxygen Concentration
I-pH = In situ Hydrogen Ion Concentration
km = Kilometer
m = Meter
MG = Million Gallons
MGAD = Million Gallons Per Acre Per Day
MGD = Million Gallons Per Day
mg/l = Milligrams Per Liter
mg/l as $CaCO_3$ = Milligrams Per Liter Expressed in $CaCO_3$ Equivalents
mg N/l = Milligrams of Nitrogen Per Liter
mg P/l = Milligrams of Phosphorus Per Liter
m^3/d = Cubic Meters Per Day
$m^3/ha \cdot d$ = Cubic Meters Per Hectare Per Day
m^3/min = Cubic Meters Per Minute
m^3/sec = Cubic Meters Per Second
mm = Millimeters
Mt. Shasta = Mount Shasta
N.A. = Not Available
NH_3-N = Ammonia Expressed as Nitrogen
N.M. = New Mexico
NO_2-N = Nitrite Expressed in Nitrogen Equivalents
NO_3-N = Nitrate Expressed in Nitrogen Equivalents
N.S. = No Sample
O & M = Operation and Maintenance
Org-N = Organic Nitrogen Expressed in Nitrogen Equivalents
SO_2 = Sulfur Dioxide
$SBOD_5$ = Soluble Biochemical Oxygen Demand

$SBOD_5$ w/N.I. = Soluble Biochemical Oxygen Demand with Nitrification Inhibitor
SCOD = Soluble Chemical Oxygen Demand
sp. = Generic Species
SS = Suspended Solids
TKN = Total Kjeldahl Nitrogen
TP = Total Phosphorus
U.C. = Uniformity Coefficient
UT. = Utah
UWRL = Utah Water Research Laboratory
VSS = Volatile Suspended Solids
W. = Watts
wks = Weeks

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SECTION 1

INTRODUCTION

NATURE OF THE PROBLEM

The waste stabilization pond is one of the oldest wastewater treatment systems and is still being used in over 3000 communities in the United States. Ninety percent of these communities have populations of 10,000 or less (Caldwell, Parker and Uhte, 1973). This treatment system is used mainly in small municipalities because of the need for a large area of land. The attractive characteristics of the system are the requirement for few operating personnel and the low economic impact.

The development of intermittent sand filters to polish lagoon effluent in order to meet stringent discharge requirements has been proven to be feasible in laboratory-scale and pilot experiments (Marshall and Middlebrooks, 1974; Reynolds et al., 1974; Harris et al., 1975; Hill et al., 1976; Bishop et al., 1976; Messinger et al., 1976; Tupyi et al., 1977).

Intermittent sand filters have been shown to be as economical and technically simple as lagoons to operate. Many communities with existing wastewater stabilization ponds plan to add or have already added intermittent sand filters to meet present or future discharge requirements.

OBJECTIVES

The general objective of this study is to evaluate the performance and the operational and maintenance characteristics of intermittent sand filtration of wastewater stabilization pond effluent.

To fulfill the general objective, the following specific objectives were undertaken:

1) Select three existing intermittent sand filter facilities representing various regions and climates of the country for performance evaluation.

2) Document the parameters and procedures employed in the design and construction of the facilities selected for study.

3) Collect operational and performance data for three 30 consecutive day periods at the three selected sites.

4) Evaluate and compare the operational and performance data collected from the selected sites with results of previous intermittent sand filtration studies.

5) Develop a typical intermittent sand filter design based on the results of the study.

6) Develop an economic analysis for the typical intermittent sand filter system developed.

7) Develop a set of guidelines for effective operation of intermittent sand filter systems.

SECTION 2

CONCLUSIONS

The following conclusions are based on an evaluation of three lagoon-intermittent sand filter systems designed to remove algal cells from lagoon effluents.

1. The Ailey, Georgia, wastewater treatment plant required the least maintenance. Operation of the intermittent sand filters required raking only three times during one year of operation and no filter sand was removed.
2. The Moriarty, New Mexico, wastewater treatment facility exhibited an acceptable level of maintenance, primarily consisting of numerous rakings and one cleaning of the filters in one year of operation.
3. The City of Mt. Shasta water pollution control facility demonstrated the greatest maintenance requirements. This was primarily caused by the lack of operational experience.
4. The best intermittent sand filter system design is a simple system which provides a minimum of opportunities for malfunctions and operational variations. The Ailey, Georgia, facility best exemplified this type of system.
5. The simplest design with automatic operation still requires maintenance to ensure trouble-free service.
6. Providing rest periods between filter loadings appears to extend the length of the filter run.
7. Lower hydraulic loading rates promote longer filter run times.
8. Slow sand filter operations produced results similar to those obtained with intermittent sand filters but short filter run times were observed with the slow sand filter operation.
9. In locations where periods of heavy precipitation occur, control of the hydraulic loading rate to the filters is necessary to prevent the shortening of the filter run time.
10. In arid climates with wind blown soil, filters should be monitored and kept clean of wind blown soil accumulations of the filter surface.

11. In locations where the local water supply has high alkalinity and hardness, the precipitation of calcium carbonate caused by the photosynthetic induced rise in pH can shorten filter run times.

12. Vegetation removal from the filter surface is an important segment of an intermittent sand filter maintenance program.

13. The use of large road maintenance and building equipment to clean large intermittent sand filters can lead to excessive removal of filter media. Cleaning equipment should be specified that will provide accurate sand removal.

14. Using a custom built filter cleaning device, the efficient cleaning of large filters can be accomplished with a minimal loss in filter media.

15. Smaller filters can be effectively cleaned by manual methods or with the aid of mechanical equipment such as small tractors equipped with a blade and loader.

16. Distribution systems for the intermittent sand filters should not be complex and should be designed to easily accommodate mechanical equipment in the maintenance of the filters.

17. Filter run times exceeded four months under normal operation at the Ailey, Georgia, facility.

18. The wastewater stabilization ponds with intermittent sand filters produced a mean effluent concentration of biochemical oxygen demand (BOD_5) as follows: Mt. Shasta, 14 mg/l or less; Moriarty, 21 mg/l or less; and Ailey, 10 mg/l or less.

19. The three intermittent sand filter facilities evaluated in this study removed 85 percent of the biochemical oxygen demand (BOD_5) 8 of the 9 sampling periods.

20. The three intermittent sand filter facilities removed 85 percent of the influent suspended solids concentrations 7 of the 9 sampling periods. The mean effluent suspended solids concentrations were: Mt. Shasta, 21 mg/l or less; Moriarty, 23 mg/l or less; and Ailey, 17 mg/l or less.

21. Without chlorination the geometric mean effluent fecal coliform concentrations were less than 91 organisms per 100 ml during all of the sampling periods.

22. The pH values for the filter effluents ranged between 6.0 and 7.7 at Mt. Shasta, 7.5 and 8.5 at Moriarty, and 6.4 and 7.7 at Ailey.

23. The effective sizes of the filter media used at the three study sites were 0.20, 0.25, and 0.37 mm. Effective sand size did not

have a significant effect on the filter run length or effluent quality.

24. The performance of the Ailey, Georgia, wastewater treatment plant was consistently better than the other systems studied.

25. Significantly poorer performance occurred only during periods associated with operational problems.

26. Heavy chlorination of the filter effluent produced a statistically significant reduction in BOD_5, $SBOD_5$ and nitrogen concentrations at the Mt. Shasta and Ailey facilities.

27. Chlorination of the wastewater prior to application to the intermittent sand filters at the Moriarty, New Mexico, facility inhibited the biological activity in the filters and resulted in little BOD_5 removal and minimal oxidation of nitrogen compounds within the filters.

28. The removal mechanisms in intermittent sand filters responsible for BOD_5 and nitrogen compounds are a combination of physical and biological processes.

29. The primary removal mechanism for suspended solids is the physical filtering properties of the filter media.

30. The reduction of fecal coliform bacteria by the intermittent sand filters ranged from 85-95 percent. The filter effluent concentrations were always less than 100 organisms/100 ml.

31. The removal of chemical oxygen demand (COD) in intermittent sand filters is less effective than the removal of biochemical oxygen demand (BOD_5).

32. The Moriarty, New Mexico, facility experienced the largest reduction of alkalinity through the filters. This reduction was probably related to the precipitation of calcium carbonate induced by the change in pH due to the photosynthetic action of the algae.

33. Total phosphorus removal by the intermittent sand filters was minimal at the three sites.

34. Intermittent sand filters are an excellent device for producing a nitrified effluent. The degree of nitrification is related to the hydraulic loading rate and the filter influent nitrogen concentration.

35. During 8 of the 9 sampling periods, the intermittent sand filters provided greater than 90 percent removal of the total algal population.

36. Annual capital costs for all existing or planned (16 systems) intermittent sand filtration facilities to upgrade lagoon effluent ranged from \$0.01 to \$0.11 per m^3 of filtrate. Annual capital costs for the Ailey, Moriarty, and Mt. Shasta filters were \$0.015, \$0.03, \$0.05 per m^3 of filtrate, respectively.

37. Annual operation and maintenance costs for the three sites monitored during this study ranged from \$0.005 to \$0.01 per m^3 of filtrate.

38. The total annual cost for upgrading lagoon effluent to meet the 1972 federal secondary treatment discharge standards ranged from \$0.04 to \$0.06 per m^3 of filtrate for the three systems studied.

39. The use of mechanical devices for cleaning intermittent sand filters will permit larger filters and prolong filter service life.

SECTION 3

RECOMMENDATIONS

1. Conduct a continuing evaluation of the filter run times observed at existing lagoon-intermittent sand filter systems. Such a study could be conducted by correspondence with plant operators.

2. Emphasize the importance and need for proper operation and maintenance of lagoon-intermittent sand filter systems. Although one of the most cost effective systems available to small communities, the system should not be advocated on the basis of requiring essentially no operation and maintenance.

3. Require that operator training be provided before transferring responsibility to the owner. The need for intelligent decisions, concern for the environment, and individual pride in operation performance must be stressed in a training program.

4. Encourage state regulator agencies or state educational systems to provide training in the basic laboratory skills for operators of small wastewater treatment facilities.

SECTION 4

LITERATURE REVIEW

INTRODUCTION

Wastewater stabilization ponds or lagoons have been in use for many centuries, but the intermittent sand filter is a relative newcomer in the area of wastewater treatment. These two processes have found a new application in a complementary combination to produce high quality wastewater treatment.

There have been six lengthy and detailed literature reviews discussing the history, theory, design, operation, performance, modeling, and economics of intermittent sand, slow sand, rapid sand, and other media filtration of potable water and wastewater (Marshall and Middlebrooks, 1974; Harris et al., 1975; Hill et al., 1976; Bishop et al., 1976; Messinger et al., 1976; Tupyi et al., 1977). These previous literature reviews provides interesting background and basic knowledge in understanding the intermittent sand filtration process used to upgrade lagoon effluents. This literature review presents a brief history of intermittent sand filtration of wastewater and concise presentation of the previous studies performed at Utah State University concerning intermittent sand filtration to upgrade lagoon effluents.

HISTORY

Intermittent sand filtration, first used as a sole wastewater treatment process, was probably a variation of the slow sand filtration process used for culinary water treatment as far back as 1828 (Daniels, 1945). In the 1870's intermittent sand filters were used in England when wastewater was applied to a tract of land at a rate of 5616 cubic meters per hectare per day (m^3/ha·d) and later reduced to 1498 m^3/ha·d by acquisition of more filter area (Pincince and McKee, 1968). From this early beginning, time and experience dictated several changes in design and operation, such as the application of settled sewage which resulted in better effluent quality and longer filter runs.

The Lawrence Research Station, Lawrence, Massachusetts, began studies of intermittent sand filters in 1887 to develop the best design and operational parameters. The resulting success encouraged the spread of intermittent sand filtration through the country as a sewage treatment process (Massachusetts Board of Health, 1912).

A renewed interest in intermittent sand filtration was initiated at the University of Florida when the post World War II population boom created the need for an economical treatment process suitable for the geographical location and the high ground water level in Florida. The study at the University of Florida utilized eight 0.69 m^2 pilot filters to treat settled sewage in an attempt to improve the performance and operation of the intermittent sand filtration process. Until the recent studies at Utah State University, the majority of literature and practical knowledge of intermittent sand filtration was developed at the University of Florida (Calaway et al., 1952; Furman et al., 1955; Grantham et al., 1949).

Population growth throughout the country, mainly in the metropolitan areas, concentrated the wastewater problems, leading to sophisticated treatment processes that required less area and more monitoring and manpower. The intermittent filtration process slowly disappeared due to the increased volume of wastewater requiring treatment and the lack of available land (Marshall and Middlebrooks, 1974).

INTERMITTENT SAND FILTRATION TO UPGRADE LAGOON EFFLUENT

Upgrading lagoon effluents has become a necessary task for the many communities that use lagoons for wastewater treatment since the passage of PL 92-500 in 1972. Middlebrooks et al. (1974) found that of the available techniques to upgrade lagoon effluent, the intermittent sand filter offered the best economical results.

Since that time, six research projects evaluating intermittent sand filtration and variations of the process have been completed at Utah State University. Table 1 is a summary of the experimental design criteria and the resulting performance for the best overall performing effective size filter sand (i.e. 0.17 mm (millimeter)), in relation to the other experimental parameters and four common performance variables (i.e. suspended solids, volatile suspended solids, five-day biochemical oxygen demand (BOD_5), and estimated costs).

Single Stage Pilot Scale and Laboratory Scale Intermittent Sand Filters

Marshall and Middlebrooks (1974) evaluated laboratory and pilot scale intermittent sand filtration of facultative lagoon effluent as a possible means of upgrading the effluent quality to meet stringent effluent standards. The performance of the process was compared to the State of Utah Class "C" Water Quality Standards (Table 2).

Of specific interest was the ability of the intermittent sand filter to remove high algae concentrations common to lagoon effluents during the warmer months of lagoon operation. Effluent from the Logan City wastewater stabilization ponds was used in both the laboratory and pilot scale phases of this research.

TABLE 1. INTERMITTENT SAND FILTRATION STUDIES PERFORMED AT UTAH STATE UNIVERSITY

Intermittent Sand Filtration Studies Author & Date	Laboratory Scale - Pilot Study *Marshall* 1974	Prototype Study *Harris* 1975	Series Intermittent Study *Hill* 1976	Dairy Waste Lagoon Study *Messinger* 1976	Aerated Lagoon Study *Bishop* 1977		Effective Size and Loading Study *Tupyi* 1977
Experimental Design							
Lagoon Type	Facultative	Facultative	Facultative	Anaerobic	Aerated & Facultative		Facultative
Sand - (e.s. mm) - (U.C.)	0.17 0.35 0.72 5.8 3.8 2.6	0.17 9.74	0.17 0.40 0.72 6.2 1.95 2.1	0.17 0.40 N.A. N.A.	0.17 0.40 9.73 4.78		0.17 0.31 0.40 0.68 9.7 6.5 5.5 5.1
Loading Rates (MGAD)*	Laboratory 0.1 0.2 0.3 Field Filters 0.1 thru 0.9	Field Filters 0.2 0.4 0.6 0.8 1.0 1.0	Phase I 0.5 1.0 1.5 Phase II - IV See Reference	Phase I 0.5 1.0 1.5 Phase II 0.1 0.35 0.5	Facultative 0.25 0.5 1.0 Aerated 0.5 1.0		0.17 Filter 0.2 0.4 Other Filters 1.0 1.5 2.0 3.0
Parameters Evaluated List	SS VSS BOD See Reference	SS VSS BOD COD pH DO Total P $O\text{-}PO_4$ NH_3-N NO_2-N NO_3-N Temp	SS VSS BOD pH DO Temp	SS VSS BOD Temp	SS VSS BOD pH Do Temp BOD		SS VSS BOD See Reference
Results for the Best Overall Performing 0.17 mm Effective Size Sand Filters							
Loading Rates* (MGAD)	0.1 0.2 0.3	0.2 0.4 0.6 0.8 1.0 1.0	0.5 1.0 1.5	0.1 0.35 0.5	0.25 0.5 1.0		0.2 0.4
Suspended Solids					Facultative	Aerated	
Average Applied mg/ℓ	13.7 13.7 13.7	30.3 30.1 34.0 23.9 28.5 24.3	32.4 32.4 32.4	353 208 194	70.7 197 108	158 68.7	23.0 20.8
Average Effluent mg/ℓ	3.96 4.80 6.05	3.5 2.9 5.9 4.7 5.1 3.7	8.6 7.8 6.4	45.5 46.5 45.1	10.1 15.6 11.8	52.5 32.9	2.7 3.5
Percent Removal	71 65 56	88 90 83 80 82 85	74 76 80	87 78 77	86 92 89	67 52	88 83
Volatile Suspended Solids							
Average Applied mg/ℓ	9.16 9.16 9.16	23.0 22.5 25.9 15.2 21.5 18.6	21.9 21.9 21.9	264 162 175	38.8 155 83.0	71.1 36.6	17.8 18.5
Average Effluent mg/ℓ	1.99 2.14 3.48	1.3 3.4 3.1 1.2 2.5 1.6	3.3 3.2 3.3	28.1 35.3 35.7	6.5 11.9 8.8	13.2 11.3	1.0 2.3
Percent Removal	78 77 75	94 85 88 92 88 91	85 85 85	89 78 80	83 92 89	81 69	95 88
Biochemical Oxygen Demand							
Average Applied mg/ℓ	6.3 6.3 6.3	19.5 20.6 25.6 2.8 13.5 6.1	10.7 10.7 10.7	123 108 107	20.2 71.4 34.0	34.4 19.6	10.9 11.5
Average E fluent mg/ℓ	1.2 1.3 2.0	1.9 2.5 4.2 1.8 2.6 2.2	1.8 2.0 2.3	19.5 43.7 67.6	6.6 9.4 13.0	5.1 11.7	1.1 2.6
Percent Removal	82 80 69	90 88 84 36 81 64	83 82 79	84 60 37	67 87 62	85 40	90 77
Estimated Cost of Filtrate with Federal Assistance (0.17 mm E.S.)	\$47 per M.G.F. @L.R.-0.3 MGAD \$33 per M.G.F. @L.R.-0.8 MGAD D.F. - 1.0 MGD	\$33 per M.G. Filtrate @ Design Flow 0.5 M.G. Day Loading Rate 0.6 M.G. Acre Day	\$44 per M.G.F. @D.F. - 0.5 MGD L.R. - 1.5 MGAD Three Filter Series	\$5.40 - \$8.48 Per Cow Year @ 8 Gal/Cow/Day	\$49 per M.G. Filtrate @ Design Flow 0.5 M.G. Day L.R. 0.25 M.G. Acre Day (using aerated lagoons)		\$236/M.G.F. @ L.R. = 0.2 MGAD \$70/M.G.F. @ L.R. = 0.4 MGAD D.F. = 1.0 MGD

*1 MGAD = 1 million gallons per acre per day = 9359.9 $m^3/h \cdot d$

SS = suspended solids
VSS = volatile suspended solids
BOD = biochemical oxygen demand
DO = dissolved oxygen
Total P = total phosphorus
$O\text{-}PO_4$ = orthophosphate phosphorus
NH_3-N = ammonia nitrogen
NO_2-N = nitrate nitrogen
MG = million gallons
MGD = million gallons per day
MGF = million gallons of filtrate
NO_3-N = nitrate oxygen
Temp = temperature

e.s. = effective size
U.C. = uniformity coefficient
L.R. = hydraulic loading rate
D.F. = design flow rate
M.G. = million gallons
M.G.F. = million gallons of filtrate

TABLE 2. CLASS "C" STREAM STANDARDS FOR THE STATE OF UTAH (UTAH STATE BOARD OF HEALTH, 1974, WATER QUALITY STANDARDS)

Parameter	Concentration or Unit
pH	6.5 - 8.5
Total Coliform, Monthly Arithmetic Mean	5,000/100 mℓ
Fecal Coliform, Monthly Arithmetic Mean	2,000/100 mℓ
BOD_5, Monthly Arithmetic Mean	5 mg/ℓ
Dissolved Oxygen	5.5 mg/ℓ
Chemical and Radiological	PHS Drinking Water Standards

The laboratory scale study (Phase I) was completed using nine 15 cm diameter x 1.85 m plexiglass cylinders. The nine columns were divided into three columns for each effective size sand. Three hydraulic loading rates were used (see Table 1). Each column had 0.71 m of sand with three 7.6 cm layers of graded underdrain gravel.

The field pilot scale study (Phase II) was performed using nine 1.2 m x 1.2 m x 1.8 m high fiberglass reinforced plywood filters. Each filter had 0.76 m of the appropriate size sand and three 10.2 cm layers of underdrain gravel. Six of the nine filters contained 0.17 mm effective size (e.s.) sand and three contained 0.72 mm e.s. sand.

Effluents from both laboratory and pilot scale filters were monitored for suspended solids, volatile suspended solids, biochemical oxygen demand, ammonia-N, nitrite-N, nitrate-N, pH, orthophosphate-P, total unfiltered phosphorus, total coliform, temperature, and algae counts. Algal bioassays were also conducted.

Within the range of hydraulic loading rates evaluated, the variation in hydraulic loading rate was found to have a minimal effect on the effluent quality. Filter run time was decreased with increased loading rates.

The effective size of the sand was found to be the most important criterion in governing the solids removal performance. The 0.17 mm e.s. sand size produced the best overall effluent, with better oxidation of nitrogen compounds, algal concentrations, suspended solids removal, and BOD_5 removal (Table 1).

The sand size was found to be directly related to the filter run time, with the 0.17 mm e.s. sand producing the lowest run times in relation to a common loading rate. The conclusion was that intermittent sand filtration could produce an effluent consistent with the State of Utah Class "C" standards.

A cost analysis of the construction and operation of the process produced an estimated range of \$26 to \$145 per million gallons of filtrate (\$0.00687 to \$0.0385 per m^3). Table 1 reports the costs with federal assistance.

Single Stage Prototype Intermittent Sand Filters

The feasibility of using prototype 0.17 mm effective size (e.s.) intermittent sand filters to upgrade lagoon effluent was evaluated by Reynolds et al. (1974). The experimental facility was constructed at the Logan City wastewater stabilization ponds. Harris et al. (1975) evaluated the performance characteristics and seasonal operation of the facility for a period of one year.

The six full scale prototype filters (7.6 m x 11.0 m) consisted of compacted earthen banks with plastic liners and PVC piping. Each of the six filters had the appropriate layers of underdrain gravel with 0.91 m of 0.17 mm effective size (e.s.) sand. Hydraulic loading rates employed and the parameters evaluated are listed in Table 1. During winter operation, various types of modifications to control ice formed on the filter surface were evaluated. These modifications included furrowing, staking and continuous flooding (constant head). All modifications were found to produce satisfactory results.

The effluent in general was found to be capable of meeting stringent water quality standards. The filters exhibited excellent oxidation of nitrogen compounds but produced negligible phosphorus reduction. It was found that the effluent quality was independent of influent quality, but increased hydraulic loading rates tended to slightly decrease the effluent quality. As the temperature decreased, the effluent quality was effectively decreased, but decreased temperature presented no particular operational problems. The flooded mode of operation created anaerobic conditions within the filter which resulted in a decrease in effluent quality and a shorter filter run time.

The length of filter run time was found to be greatly affected by the time of day the filters were loaded and calcium carbonate precipitation. An experiment performed by Reynolds et al. (1974) indicated that loading during daylight hours would increase algae concentrations in the water standing on the filters and suggested that dosing after dark would eliminate the increase in solids due to photosynthesis. Calcium carbonate precipitation occurred when the water remained on the surface of the filters and algae growth increased the pH of the water. As the pH increased, carbonate ions precipitated when the solubility product of the carbonate was exceeded at high pH values. This precipitation creates a cementation of the sand surface and decreases filter run time.

The filter run length was related to the suspended solids concentration and the hydraulic loading rates. It was determined that hydraulic loading rates between 3744 and 5616 m^3/ha·d would be the optimum economical loading rates for 0.17 mm sand filters. The average lengths of filter runs for the 1872, 3744 and 5616 m^3/ha·d loading rates were 64, 33, and 18 days, respectively.

A cost analysis of construction of the prototype filters produced a cost range of $33 to $70 per million gallons of filtrate ($0.0087 to $0.0185 per m^3) with federal assistance (Table 1). Without federal assistance the cost of construction was estimated to range between $66 and $140 per million gallons of filtrate ($0.0174 to $0.037 per m^3).

Series Field Pilot and Laboratory Scale Intermittent Sand Filters

The success of the single stage intermittent sand filters could only be improved by increasing the length of filter run. Hill et al. (1976) evaluated the feasibility of using series pilot scale and laboratory scale intermittent sand filters to upgrade lagoon effluent. The quality of effluent and the effectiveness of increasing the filter run time was compared to previous results obtained with single stage intermittent sand filters (Reynolds et al., 1974; Harris et al., 1975).

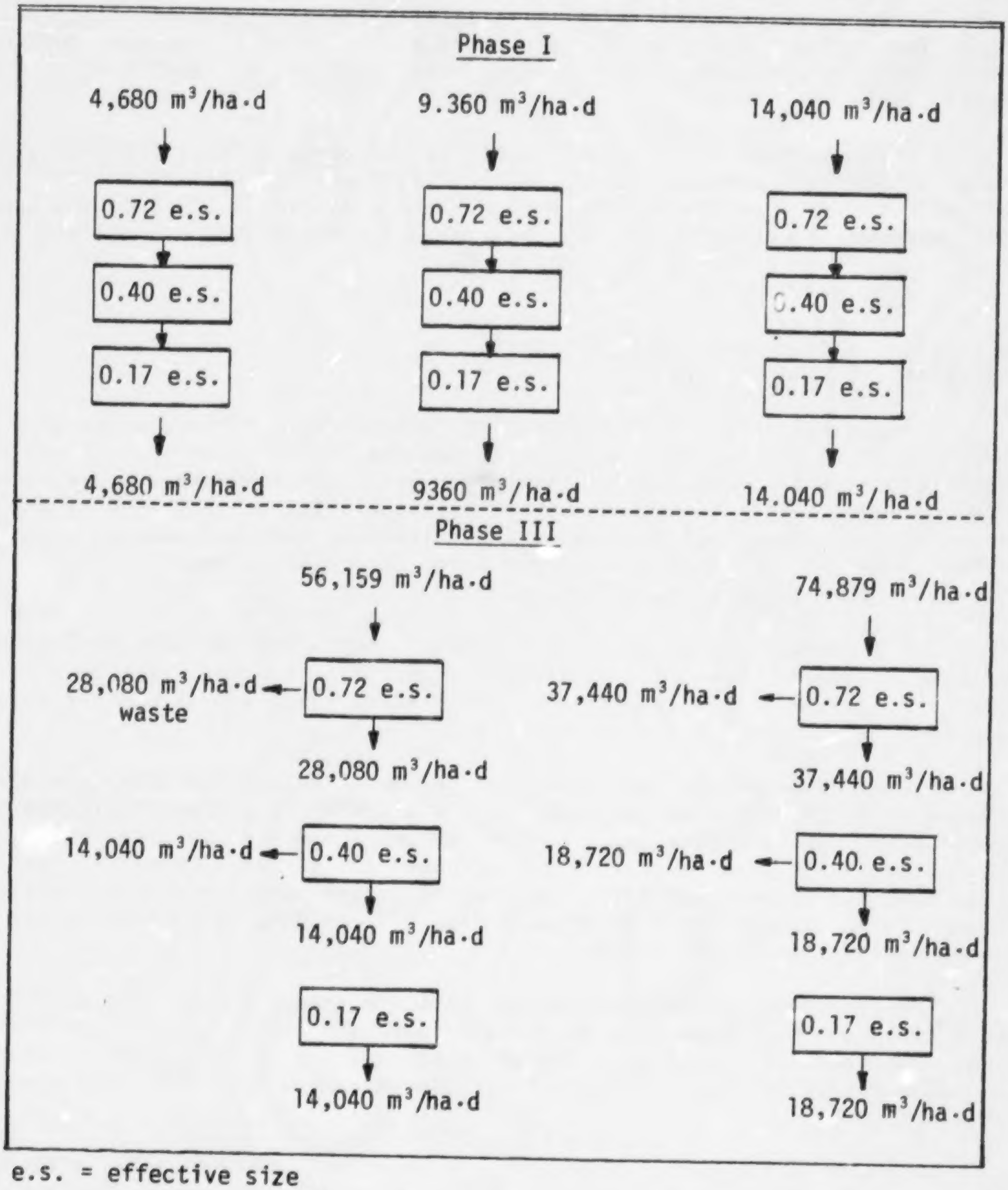
The study was conducted in four phases, each using facultative lagoon effluent from the Logan City wastewater stabilization ponds. The four phases consisted of two categories: field pilot scale and laboratory scale studies.

The major portion of the study was performed on the field pilot scale system which consisted of the nine 1.2 m x 1.2 m x 1.8 m high fiberglass reinforced plywood filter units used by Marshall and Middlebrooks (1974). The filter units were rearranged and prepared for series operation. The resulting arrangement was three independent series operations with the sand sizes in the three filters decreasing from 0.72 to 0.40 to 0.17 mm as the water passed through the system.

The laboratory study utilized one series system with the same 0.76 m sand depth and 0.30 m of layered gravel underdrain as the pilot scale system. The sand and gravel were placed in 15 cm diameter PVC cylinders with a 0.30 m length of clear plexiglass cylinder arranged for sand surface observation.

As shown in Figure 1, Phase I of the study utilized hydraulic loading rates of 4680, 9360, 14,040 m^3/ha·d on the three 3-filter series systems.

Phase II was the laboratory scale study performed at the Utah Water Research Laboratory. The loading rate was initially started at 112,319 m^3/ha·d but due to plugging was reduced to 74,879 m^3/ha·d then to 37,440 m^3/ha·d. Phase III went back to the field pilot scale filters using a decreasing loading scheme on two of the three series systems as shown in Figure 1. Phase


Phase I
4,680 m³/ha·d
9.360 m³/ha·d
14,040 m³/ha·d
0.72 e.s.
0.40 e.s.
0.17 e.s.
4,680 m³/ha·d
9360 m³/ha·d
14.040 m³/ha·d
Phase III
56,159 m³/ha·d
74,879 m³/ha·d
28,080 m³/ha·d waste
0.72 e.s.
37,440 m³/ha·d
0.72 e.s.
28,080 m³/ha·d
37,440 m³/ha·d
14,040 m³/ha·d
0.40 e.s.
18,720 m³/ha·d
0.40 e.s.
14,040 m³/ha·d
18,720 m³/ha·d
0.17 e.s.
0.17 e.s.
14,040 m³/ha·d
18,720 m³/ha·d

e.s. = effective size

Figure 1. Organization of series intermittent sand filter study.

IV was an equal loading operation using two of the series systems with much higher loading rates (28,080 $m^3/ha \cdot d$ and 38,440 $m^3/ha \cdot d$) than were used in Phase I.

It was concluded that, when operated and loaded properly, series intermittent sand filtration could consistently produce a high quality effluent sufficient to meet more stringent discharge requirements than the State of Utah "C" Standards (Table 2). The series intermittent sand filters were able to treat higher hydraulic loading than the single stage filters with comparable results. The pilot scale series filters obtained run times of 130 days or greater for the 4680-14,040 $m^3/ha \cdot d$ (Phase I) loading rates (Table 1).

An economic analysis of the series intermittent sand filtration of lagoon effluent produced an estimated cost range of $39 to $44 per million gallons of filtrate ($0.0103 to $0.0116 per m^3) with federal assistance. Without federal assistance construction costs were estimated to range from $78 to $89 per million gallons of filtrate ($0.0206 to $0.0235 per m^3).

Single Stage Laboratory Scale Intermittent Sand Filtration of Anaerobic Lagoon Effluent (Dairy Parlor Wastewater Lagoon)

Messinger et al. (1976) studied the feasibility of using an anaerobic lagoon followed by an intermittent sand filter to treat dairy parlor wastewater. The PL 92-500 Federal Secondary Treatment Standards were chosen as a desired effluent quality (Table 3).

The study was performed using a laboratory scale system consisting of a 2.04 m^3 fiberglass reinforced plywood tank as the lagoon and six 15 cm diameter x 2.18 m high plexiglass and PVC cylinders used for the filters. Three of the cylinders were filled with 0.91 m of each of the two effective size sands and 23 cm of underdrain gravel (Table 1).

TABLE 3. NATIONAL SECONDARY TREATMENT STANDARDS (FEDERAL WATER POLLUTION CONTROL ACT, 1972, PL 92-500)

pH	6.0 to 9.0
Suspended Solids (SS)[a]	30 mg/l-30 day average or 45 mg/l-7 day average
BOD_5[a]	30 mg/l-30 day average or 45 mg/l-7 day average
Fecal Coliform	200/100 ml-30 day geometric mean or 400/100 ml-7 day geometric mean

[a] Treatment must also remove 85 percent of influent SS and BOD_5.

The study consisted of two phases, the first of which used loading rates of 4680, 9360, 14,040 $m^3/ha \cdot d$. Due to the poor results of Phase I, the loading rates were reduced to 936, 3276, 4680 $m^3/ha \cdot d$ for Phase II of the study. Even the lower loading rates did not provide the desired effluent quality. The removal efficiency of the filters remained relatively high, but the high organic loading rates led to rather high concentrations in the effluent (Table 1). The results indicated that the use of the 0.17 mm effective size sand and low loading rates (<4680 $m^3/ha \cdot d$) provided the best filter effluent quality when using strong anaerobic lagoon effluent. A long period of time (3 to 4 weeks) was required for a filter to recover after being heavily loaded and becoming anaerobic. It was concluded that using an anaerobic lagoon effluent with intermittent sand filters would not produce an effluent quality that would satisfy the PL 92-500 discharge requirements.

An economic analysis was performed for an eighty cow farm and the costs ranged from $5.40 to $8.48 per cow per year.

Single Stage Pilot Scale Intermittent Sand Filtration of Aerated Lagoon Effluent

Previous studies had not evaluated the use of intermittent sand filters to upgrade aerated lagoon effluent. Bishop et al. (1977) evaluated the performance of pilot scale intermittent sand filtration systems when treating aerated lagoon and facultative pond effluent (Table 1).

The aerated lagoons and adjacent facultative pond were part of a system treating wastewater from a milk processing plant. The evaluation included filter effluent quality when both the aerated lagoon and facultative pond effluents were applied to the filters. Four 1.2 m x 1.2 m x 2.4 m high pilot scale filters were constructed of fiberglass reinforced plywood. Two filters, each containing 0.91 m of the appropriate size sand and 0.30 m of layered gravel underdrain received varying hydraulic loading rates.

The filter effluent quality was affected by the effective sand size (e.s.) with the 0.17 mm e.s. sand producing the best quality effluent. Once again the run time of the filter was related to the effective size of the sand, with the 0.17 mm e.s. sand producing the shorter run time for common suspended solids and hydraulic loading rates. Increased hydraulic loading rates resulted in a decrease in BOD_5 removal and filter run time but did not affect the suspended solids or volatile suspended solids removals. A comparison of the aerated lagoon filtrate and the facultative pond filtrate showed that better removal was obtained when filtering facultative pond effluent. Intermittent sand filtration of effluent from an aerated lagoon with a facultative pond using a 0.17 mm effective size sand produced an effluent meeting present and future State of Utah discharge requirements at an estimated cost of $49 per million gallons of filtrate ($0.0129 per m^3) with federal assistance (Table 1). Construction costs without federal assistance was estimated to be $147 per million gallons of filtrate ($0.0389 per m^3).

Effective Sand Size and Filter Loading Study of Intermittent Sand Filtration of Lagoon Effluent

Previous studies have proven the ability of 0.17 mm effective size (e.s.) intermittent sand filtration to upgrade lagoon effluents to meet present and future requirements with proper design and operation. The main handicap of this system is the length of service and the labor required to reactivate the filters. In an effort to establish new design and operational criteria to minimize this liability, a study was completed evaluating the effects of varying effective sand sizes and loading rates on the quality of effluent (Tupyi et al, 1977). The effect of both hydraulic loading rates and application rates were evaluated with various effective size sands. The application rate is defined as the period of time required to apply the required volume of wastewater to the filter.

Six 11.0 m x 7.6 m prototype, vinyl lined, earthen banked, intermittent sand filters were used (Reynolds et al., 1974; Harris et al., 1975). The filter sand effective sizes were 0.17 mm, 0.31 mm, 0.40 mm and 0.68 mm.

Filter effluents were monitored for the following parameters: SS, VSS, BOD_5, COD, NH_3-N, NO_2-N, NO_3-N, TKN, total P, ortho-PO_4, alkalinity, DO, temperature, total and fecal coliforms, and algae counts. One major difference from the previous studies was the evaluation of the effects of varying the application rates of wastewater to the surface of the filter. Application rates of 0.008 m^3/sec and 0.048 m^3/sec were utilized on the three largest effective size sand filters. An application rate of 0.048 m^3/sec was used exclusively on the 0.17 mm e.s. filters.

As previously reported, the 0.17 mm e.s. size sand filter at both hydraulic loading rates (1872 and 3744 m^3/ha·d) produced an effluent which satisfied the State of Utah Class "C" BOD_5 and suspended solids standards (Table 2). The 0.40 mm e.s. filter receiving a hydraulic loading rate of 9360 m^3/ha·d and an application rate of 0.008 m^3/sec also produced an effluent which satisfied the suspended solids and BOD_5 requirements of Class "C" standards. In both cases, total and fecal coliform concentrations in the effluent did not meet the Class "C" standards even though 95 percent and greater removals were obtained with the filters.

Hydraulic loading rate was again found to have little effect on the overall quality of the effluent. The smaller effective sand size produced a more highly nitrified effluent, better coliform removal, greater algae removal and an overall superior quality effluent. The lower application rates appear to have a profound effect on the effluent quality as illustrated by the performance of the 0.40 mm e.s. sand filter. Longer filter runs were also related to lower application rates along with a higher nitrified effluent. The 0.17 mm e.s. sand filter receiving a hydraulic loading rate of 1872 m^3/ha·d operated 100 days or more before cleaning was required.

The estimated total construction cost per million gallons of filtrate for the 0.17 mm e.s. size filter ranged from $45 to $236 (Table 1) ($0.0119 to $0.0624 per m^3). Without federal assistance the construction costs were estimated to be \$95 to \$503 per million gallons of filtrate (\$0.0251 to \$0.133 per m^3).

SUMMARY

With proper design and operation, intermittent sand filtration is an economical process to upgrade wastewater stabilization lagoon effluent to meet present and future discharge requirements. Throughout the studies the effective sand sizes and hydraulic loading rates have been common variables. The effective sand size has been found to be the most important variable relative to quality of effluent and the ability of the process to meet effluent requirements. Hydraulic loading rate does not have a great effect on the effluent quality but does play an important role in the economics of filter run time. Lengthening the filter run time requires either a decrease in loading rate which in turn creates a larger initial construction cost along with increased maintenance costs, or a sacrifice in the quality of effluent. Neither variation guarantees any consistent run time because lagoon effluent quality can fluctuate greatly during the year and can increase or decrease the filter run time.

In relation to the more sophisticated treatment processes available to small municipalities, the intermittent sand filter following a wastewater stabilization lagoon offers an effective treatment process at a lower cost.

SECTION 5

METHODS AND PROCEDURES

FACILITY SELECTION

Three new existing intermittent sand filters used to upgrade wastewater stabilization ponds were selected to represent various regions and climates of the country. The range of design flows, availability of laboratory facilities, and design criteria were of equal importance in the selection. The location and description of the three facilities selected are presented in Table 4. More detailed descriptions of the communities and wastewater treatment facilities are presented below.

FACILITY LOCATION AND DESCRIPTION

City of Mount Shasta, California

Water Pollution Control Facility--

The City of Mount Shasta is located in Northern California approximately 387 km north of Sacramento on Interstate Highway 5. The city is situated on the mountainous southwest slope of Mount Shasta at an elevation of approximately 1005 m above mean sea level. The primary economic activity is logging and the community has a population of 2517 (1970 census) with an estimated growth to 3000 by 1984. The area has a mild climate for a mountain region with an annual mean precipitation of 89 cm and average monthly temperatures ranging from -4°C to 29.5°C.

The Water Pollution Control Facility is located 3.5 km southwest of the downtown area along the Sacramento River gorge. The facility was placed in operation in the Fall of 1976. The average dry weather design flowrate is 2650 m^3/d and the average wet weather flow is 4542 m^3/d.

The lagoon system consists of four aerated lagoons (Figure 2), two 3.05 m deep primary lagoons and two 0.91 m deep secondary lagoons. The total surface area of the lagoons is 3.2 hectares with a volume of 54,207 m^3. The lagoons were constructed of compacted earth dikes without an impermeable liner or slope stabilization. The aerated lagoons provide a retention time of 20.5 days at a flow rate of 2658 m^3/d and 12.0 days at 4542 m^3/d. Aeration is supplied by a Hinde Engineering System[1] using four 7457 w blowers. A

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[1] Hinde Engineering Co., Highland Park, Illinois.

TABLE 4. FACILITY DESIGN CRITERIA[a]

Facility	Mount Shasta Water Pollution Control Facility	Moriarty, N.M. Wastewater Treatment Facility	Ailey, Georgia Sewage Treatment Plant
Design Flow Rate	Dry weather 0.7 MGD Wet weather 1.2 MGD	0.4 MGD maximum 0.2 MGD normal	0.080 MGD
Lagoons			
Number/type/size/depth/capacity			
Primary	2/aerated/1.4 acres/10 ft/3.2 MG	2 aerated/0.4 acre/10 ft/1.0 MG	1/facultative/5.5 acres/3.5 ft/4.8
Secondary	2/aerated/4.2 & 3.4/5 ft/3.4 & 2.8 MG	2/facultative/1.2 acres/3 ft/1.1 MG	1/facultative/0.75 acre/3.0 ft/0.8
Total retention time	12 days to 20.5 days	10 days to 20 days	70 days
Filters			
Number/area of each filter	3/1.0 acre (6/0.5 acre)	8/0.082 acre	2/0.14 acre
Design loading rate	0.7 MGAD	0.6 MGAD	0.4 MGAD
Media			
Sand			
Effective size (mm)	0.37	0.20	0.50
Uniformity coefficient	5.1	4.1	4.0
Depth	24 inches	24 inches	30 inches
Underdrain			
Layer depth/gravel size	18 in./coarse, 4 in./medium 3 in./fine, 3 in./coarse sand	4 in./pea gravel, 4 in./¾ inches remaining depth of 1½ inches gravel	3 in./coarse sand, 3 in./pea gravel, 3 in./medium, coarse
Available freeboard	24 inches	18 inches	18 inches
Dosing system	Time controlled butterfly valves	Automatic siphon (25,000 gal)	Float actuated valves (18,000 gal)
Distribution system	18 inch diameter manifolds with sixteen concrete splash pads	Six redwood distribution troughs (replaced with gravel splash pads)	3-6 inch diameter lateral plastic perforated pipes
Disinfection			
Type	Gas chlorinators	Tablet type	Gas chlorinators
Contact time	63 minutes	Variable with flow	One hour
Other Points of Interest	Summer discharge is pumped to a drain field above the city	Disinfection is accomplished prior to application to the filters	Use of two lift stations are required within the facility because of flat topography

[a] Conversion to SI units

1 MGD = 3785 m^3/d
1.0 MGAD = 9.360 $m^3/ha \cdot d$
1 MG = 3785 m^3
1 acre = 0.405 hectare
1 ft = 0.30 m
1 inch = 2.54 cm

facultative ballast lagoon with a volume of 20,933 m^3 along with a large dosing basin with a volume of 5,224 m^3 provide adequate detention capacity for constant discharge through the intermittent sand filters.

Three 0.405 hectare filters are divided into six 0.202 hectare sections (101.2 m x 19.2 m) and each of the two 0.202 hectare sections are loaded from one large distribution manifold system with concrete splash pads on the filter surface. A design hydraulic loading rate of 6552 $m^3/ha \cdot d$ was used to size the filters. The filters are surrounded by earthen banks with a 1.42 m concrete block wall constructed around the periphery of the filters to retain the water and prevent sloughing of the earthen banks onto the filter surface. Filter material for the 1.32 m of media consists of 45 cm of coarse gravel, 10.2 cm of medium gravel, 7.6 cm of fine gravel, 7.6 cm of coarse sand, and 61 cm of washed concrete sand. The effective sand size is 0.37 mm with a uniformity coefficient of 5.1.

Disinfection is accomplished with a gas chlorinator[2] and a contact chamber with a 63 minute detention time at a flow rate of 2650 m^3/d. A sulfonator is used to dechlorinate before discharge to meet the State of California discharge requirements.

An unusual characteristic of the facility is that during summer operation, plant effluent is pumped a distance of two miles to a drain field above the city to prevent pollution of the Sacramento River during the low flow period. This component of the system is shown as the water reclamation system in Figure 2.

Normal operation of the intermittent sand filters consists of one day loading and two days rest while the remaining filters are loaded. The filter selected to be loaded receives two equal applications daily. When plugging occurs, the remaining filters are loaded alternately until cleaning is completed. To prevent surges in the chlorine contact tank, the filtrate is held in the filter underdrain below the sand level and released at a regulated flow rate.

Operation and maintenance duties are performed by two full time operators and one part-time operator as back up, along with city maintenance crews for heavy work such as filter cleaning operations.

Moriarty Wastewater Treatment Facility, Moriarty, New Mexico

Moriarty, New Mexico, is located on the high plains approximately 54.7 kilometers east of Albuquerque, New Mexico, on Interstate Highway 40 at an elevation of 1890 m above mean sea level. The primary industry is services (gasoline, food, lodging) for the interstate, with agriculture as a secondary activity. The population of 1200 (1970 census) which is expected to

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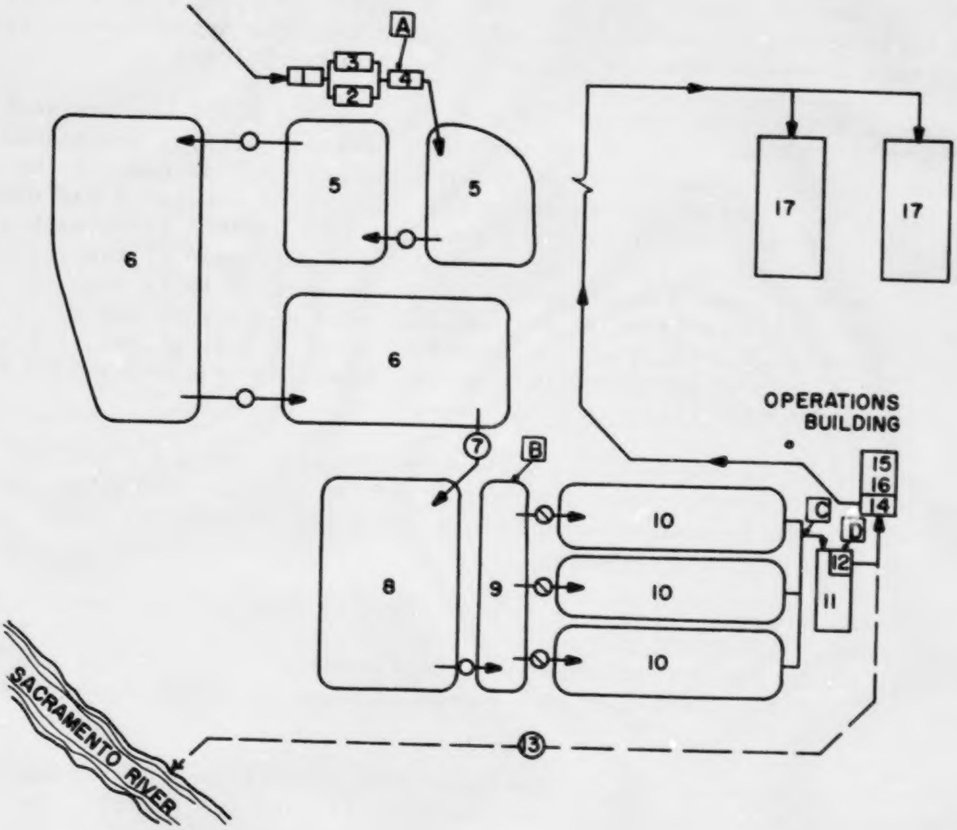
[2] Series V-800, Wallace & Tiernan Co., Belleville, N.J.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OPERATIONS BUILDING
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SACRAMENTO RIVER
13

LEGEND

1	BAR RACK
2	COMMINUTER
3	BYPASS BAR RACK
4	INFLUENT PARSHALL FLUME
5	PRIMARY AERATED LAGOONS
6	SECONDARY AERATED LAGOONS
7	LAGOON SYSTEM PARSHALL FLUME
8	BALLAST LAGOON
A	LAGOON INFLUENT SAMPLING POINT
B	LAGOON EFFLUENT SAMPLING POINT
9	DOSING BASIN
10	INTERMITTENT SAND FILTERS
11	CHLORINE CONTACT BASIN
12	EFFLUENT PARSHALL FLUME
13	RIVER DISCHARGE LINE
14	OUTFALL PUMP STATION
15	CHLORINATOR / SULFONATOR
16	AERATION BLOWERS
17	WATER RECLAMATION SYSTEM
C	FILTER EFFLUENT SAMPLING POINT
D	CHLORINATED FILTER EFFLUENT POINT

Figure 2. Mount Shasta, Ca., water pollution control facility process flow diagram.

increase to 2000 by 1985, live in a semi-arid high altitude climate with an average annual rainfall of 20.3 cm and a mean yearly temperature of 13°C.

The wastewater treatment facility is located at the east side of town near an on-off ramp for Interstate 40. The facility began discharging effluent in late Spring of 1977.

The design flow rate of 757 m^3/d was used to size the two parallel aerated primary and facultative secondary lagoon systems to achieve a design retention time of 10 days for each system with a maximum capacity of 1514 m^3 with both systems receiving maximum flow (Figure 3). Because of the climate and altitude an extremely high rate of evaporation (50 percent or greater) was anticipated in the design flow and the resulting hydraulic loading applied to the filters.

The lagoon system consists of four compacted earthen dike lagoons with concrete aprons surrounding the interior lagoon walls for bank stabilization and weed control. The two primary aerated lagoons are 3 m in depth with 0.91 m of freeboard and each having a water surface area 40.8 m x 40.8 m or 0.17 ha. Each primary lagoon contains a volume of 3785 m^3. Each aerated lagoon is equipped with a 7457 w mechanical aerator[3] with timing control devices to regulate aeration. The two facultative polishing ponds are 0.91 m deep with 0.61 m of freeboard, a surface area of 0.49 ha each, and a volume of 4163.9 m^3. Secondary lagoon effluent is collected and directed to a combination chlorine contact chamber and dosing basin, 13.6 m x 9.1 m x 1.2 m deep, equipped with a dosing siphon for automatic dosing of the filters. The effective dosing depth of 0.76 m and a volume of 94.6 m^3 is discharged per dose to the filters. The dosing cycle is relatively slow, requiring at least an hour to drain the basin because of the small differential in elevation. After the initial lift provided by the raw influent screw pumps, flow through the entire system is by gravity.

Disinfection is accomplished with a combination of four chlorinators[4] (tablet type) located at the inlet to the dosing basin. Chlorination of the wastewater is accomplished prior to application to the filters.

The intermittent sand filters consist of eight 18.3 m x 18.3 m concrete basins with four filters located on each side of a common distribution manifold with manual valves and a common collecting drain line beneath the distribution line. Distribution onto the filters is accomplished by discharging effluent from the dosing siphon into a six-outlet manifold with discharges into six redwood distribution troughs. The redwood troughs were later removed because of poor performance and replaced with gravel splash pads. The filter profile consists of 0.61 m of 0.20 mm effective size sand with a uniformity coefficient of 4.1, 10.2 cm of 0.64 cm pea gravel, 10.2 cm of 1.9 cm gravel and the remaining portion of the underdrain system is filled with 3.8 cm rock.

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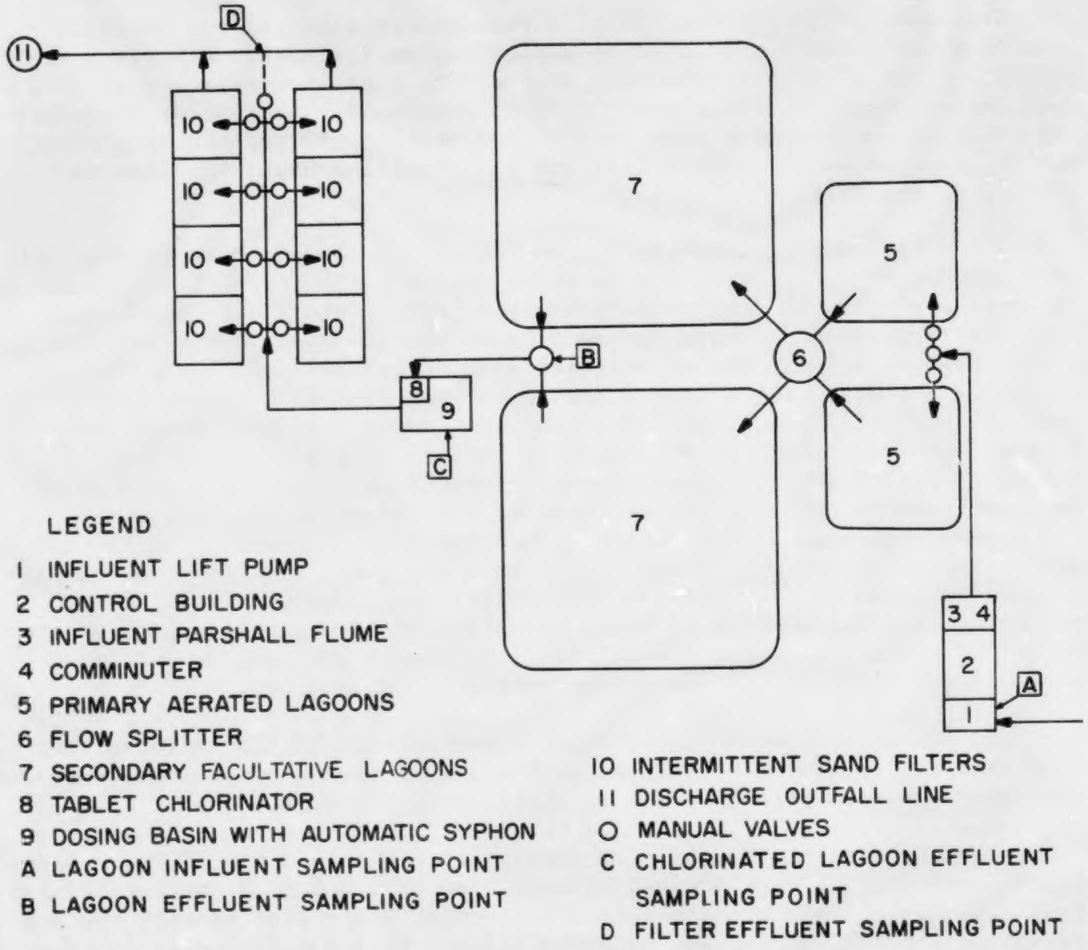
[3] Aqua Aerobic Systems, Inc., Rockford, Illinois.

[4] Sanuril Model 100, Electrode Corporation, Chardon, Ohio.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C
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3 4
2
A
1
LEGEND
1 INFLUENT LIFT PUMP
2 CONTROL BUILDING
3 INFLUENT PARSHALL FLUME
4 COMMINUTER
5 PRIMARY AERATED LAGOONS
6 FLOW SPLITTER
7 SECONDARY FACULTATIVE LAGOONS
8 TABLET CHLORINATOR
9 DOSING BASIN WITH AUTOMATIC SYPHON
A LAGOON INFLUENT SAMPLING POINT
B LAGOON EFFLUENT SAMPLING POINT
10 INTERMITTENT SAND FILTERS
11 DISCHARGE OUTFALL LINE
O MANUAL VALVES
C CHLORINATED LAGOON EFFLUENT SAMPLING POINT
D FILTER EFFLUENT SAMPLING POINT

Figure 3. Moriarty, N.M., wastewater treatment facility process flow diagram.

Normal operation consists of automatic loading of the filters with the dosing siphon, and the frequency of dosing varies with the flow rate. The dosing volume 94.6 of m^3 is distributed over two of the eight filters. At the design flow rate of 378 m^3/d (with a 50 percent evaporation rate), the hydraulic loading rate on the filters is 5616 $m^3/ha\cdot d$. When plugging occurs the next two filters are put into operation and so on, leaving adequate time for filter cleaning and recycling.

Manpower requirements are minimal due to automatic operation. Four inspection visits are conducted daily and chlorine residual in the effluent and flow rate are monitored by a part-time employee also involved in other city duties. Maintenance work is done by other city employees.

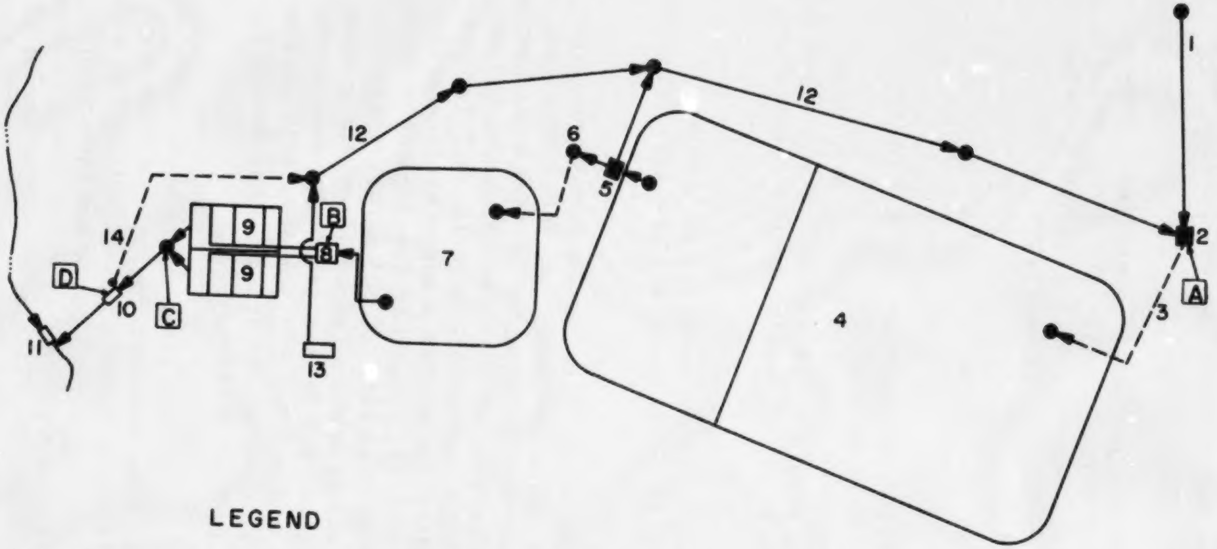
City of Ailey, Georgia, Sewage Treatment Plant

The City of Ailey, Georgia, is located in southeast Georgia on the heavily forested coastal plain, about 136 km west of Savannah on U.S. Highway 280. At an elevation of 51.8 m above mean sea level, the predominantly lumber oriented community of 400 people enjoy a mild but wet climate, with an average yearly rainfall of 122 cm and an average annual temperature of 19.5°C.

The sewage treatment plant is located approximately 2 km northwest of downtown Ailey on Bear Creek (Figure 4). The plant was put into operation in the Fall of 1976.

The average design flow rate is 303 m^3/d. The lagoon system consists of two 1.07 m deep primary facultative oxidation ponds and one 1.07 m deep facultative polishing pond. The lagoons are constructed of compacted earthen dikes with concrete aprons around the inside for bank stabilization and weed control. The primary lagoons have a total water surface area of 2.2 hectares and a volume of 18,170 m^3. The secondary lagoon has a water surface area of 0.30 ha with a normal capacity of 3028 m^3. Together the lagoons provide 70 days of retention time for the design flow rate of 303 m^3/d. A flow splitter located between the primary and secondary lagoons provides a means to recirculate the primary lagoon effluent for better treatment when necessary. A concrete dosing basin of 8.5 m x 8.5 m x 1.5 m deep adds 68.1 m^3 of lagoon effluent per dosing to the filters automatically. The design hydraulic loading rate for the filters is 3744 $m^3/ha\cdot d$.

The two 33.5 m x 16.7 m filters constructed of concrete with 45 cm of freeboard are located side by side and have separate dosing manifolds connected to three perforated laterals 15 cm in diameter distributing the water over the surface of the filter sand. During normal operation, electronic floats in the dosing basin activate two separate valves alternately to dose the filters. The alternate dosing enables the filters to rest a period of time depending on the discharge rate before being dosed again. The filter profile consists of 76.2 cm of 0.50 mm effective size sand with a uniformity coefficient of less than 4.0, 7.6 cm of coarse sand, 7.6 cm of pea gravel, 7.6 cm of medium gravel, and coarse gravel covering the underdrain system.



LEGEND

1 INFLUENT MAIN LINE
2 LIFT STATION #1
3 FORCED MAIN
4 OXIDATION POND
5 FLOW SPLITTER
A LAGOON INFLUENT SAMPLING POINT
B LAGOON EFFLUENT SAMPLING POINT

6 LIFT STATION #2
7 POLISHING POND
8 DOSING BASIN
9 INTERMITTENT SAND FILTERS
10 CHLORINE CONTACT CHAMBER
C FILTER EFFLUENT SAMPLING POINT
D CHLORINATED FILTER EFFLUENT SAMPLING POINT

11 IN-STREAM PARSHALL FLUME
12 SEWER RETURN LINE
13 CONTROL BUILDING
14 CONTACT CHAMBER DRAIN LINE

Figure 4. Ailey, Ga., sewage treatment plant process flow diagram.

Disinfection is accomplished with a gas chlorinator[5] and two parallel 3.9 m x 1.2 m x 2.1 m deep, over and under baffled contact chambers. The plant effluent is discharged over a 60°V-notch weir connected to a flow totalizer[6] and recorder to measure the discharge rate. A Parshall flume located in Bear Creek is used to measure the flow rate in the creek. The discharge permit requires that the plant discharge not exceed the flow rate in the creek.

Two pumping stations lift wastewater to required levels since the topography is relatively flat.

Manpower requirements are minimal and consist of one daily inspection during the week with flow and chlorine residual monitoring and periodic analysis of suspended solids, BOD_5, and fecal coliform for monthly reports. When physical labor is required for cleaning filters and grounds maintenance, the city maintenance crew provides the manpower.

SAMPLING AND ANALYSIS

Because of the wide geographical distribution of the lagoon-filter sites, it was necessary to use a mobile laboratory to provide adequate equipment and supplies for the nine sampling periods. A heavy duty pickup truck with a camper shell for storage and a 9.75 m self-contained travel trailer were used for equipment storage space while on the road. The trailer was used as housing for the sampling crew when working at a site. Laboratory equipment sufficient for the field analyses was carried from site to site to ensure a common base for all field analyses. The laboratory facilities at each of the systems being evaluated were used to house the field laboratory, and all analyses requiring immediate attention were conducted in the field.

Each of the three sites were monitored for three 30-consecutive-day-sampling periods during different seasons of the year, totaling 270 sampling days. Table 5 shows the duration of the sampling periods at each site. Four sampling points were selected at each site to collect 24-hour composite samples. Lagoon influent, lagoon effluent (also filter influent), filter effluent, and chlorinated effluent samples were collected at each site. The location of the sampling equipment at each of the sites is shown on Figures 2-4. The locations are identified with capital letters, with |A| representing the lagoon influent sampling station, |B| the lagoon effluent, etc. Four automatic samplers[7] in conjunction with four 0.11 m^3 recreational vehicle refrigerators[8] housed in 1.2 m x 0.91 m x 1.5 m high protective plywood buildings were used to collect the samples. Figure 5 shows a cross sectional view of the sampling apparatus.

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[5] Series V-800 Wallace Tiernan chlorinator.

[6] Sparling type 261, Envirotech, Salt Lake City, Utah.

[7] ISCO Model 1580 Automatic Wastewater Sampler, Lincoln, Nebraska.

[8] Dometic Model RM4 Recreation Vehicle Refrigerator, Sweden.

All analyses were performed according to the 14th Edition of Standard Methods (APHA, 1975). Table 6 presents a summary of the location of sampling points, the analyses conducted and the type of samples collected. Field laboratory limitations made it necessary to return preserved samples to the Utah Water Research Laboratory (UWRL) for certain analyses. Parameters measured at the UWRL are identified in Table 6. Samples shipped to the UWRL were preserved according to Standard Methods (APHA, 1975) and were shipped daily by U.S. Priority Class Mail to ensure receipt and analysis in Utah within a week from the sampling date.

In addition to the analyses performed on the wastewater, a record of operational and maintenance requirements were recorded daily by the research team and the facility operator.

TABLE 5. TABLE OF SAMPLING PERIODS (TOUR) DATES

Location	From	To	Season	Visit #
Mt. Shasta, Ca.	1/22/77	2/20/77	Winter	1
Ailey, Ga.	3/19/77	4/17/77	Spring	1
Moriarty, N.M.	5/19/77	6/17/77	Summer	1
Mt. Shasta, Ca.	7/11/77	8/20/77	Summer	2
Ailey, Ga.	9/16/77	10/14/77	Fall	2
Moriarty, N.M.	11/14/77	12/13/77	Fall	2
Ailey, Ga.	1/04/78	2/02/78	Winter	3
Moriarty, N.M.	2/14/78	3/15/78	Winter	3
Mt. Shasta, Ca.	4/14/78	4/28/78	Spring	3

TABLE 6. SAMPLING LOCATION AND DESCRIPTION

Parameter	Sample Location				Sample Type		
	Lagoon Influent	Lagoon Effluent	Filter Effluent	After Chlorination	Grab Sample	Composite Sample	Insitu
Wastewater Flow							
Daily total		×	×				
Minimum		×					
Maximum		×					
pH		×	×	×		×	×
Temperature	×	×	×				×
Dissolved Oxygen	×	×	×	×		×	×
Alkalinity	×	×	×			×	
Total BOD$_5$[a]	×	×	×	×		×	
Soluble BOD$_5$[a]	×	×	×	×		×	
Suspended Solids							
Total	×	×	×	×		×	
Volatile	×	×	×	×		×	
Fecal Coliforms	×	×	×	×	×		
Total COD[b]	×	×	×	×		×	
Soluble COD[b]	×	×	×	×		×	
Total Phosphorus[b]	×	×	×	×		×	
TKN[b]	×	×	×	×		×	
NH_3 - N[b]	×	×	×	×		×	
NO_2 - N[b]	×	×	×	×		×	
NO_3 - N[b]	×	×	×	×		×	
Algae Counts[c]		×	×	×		×	

[a] Twice during each 30-day sampling period BOD$_5$ analyses were performed with and without nitrification inhibitor in the bottle. All other samples were analyzed without the use of nitrification inhibitors. Allyl-thiourea was used as the inhibitor (Young, 1973).

[b] Samples shipped to UWRL for analysis.

[c] Algae counts were conducted once every six days of sampling. Samples were preserved and returned to UWRL for counting.

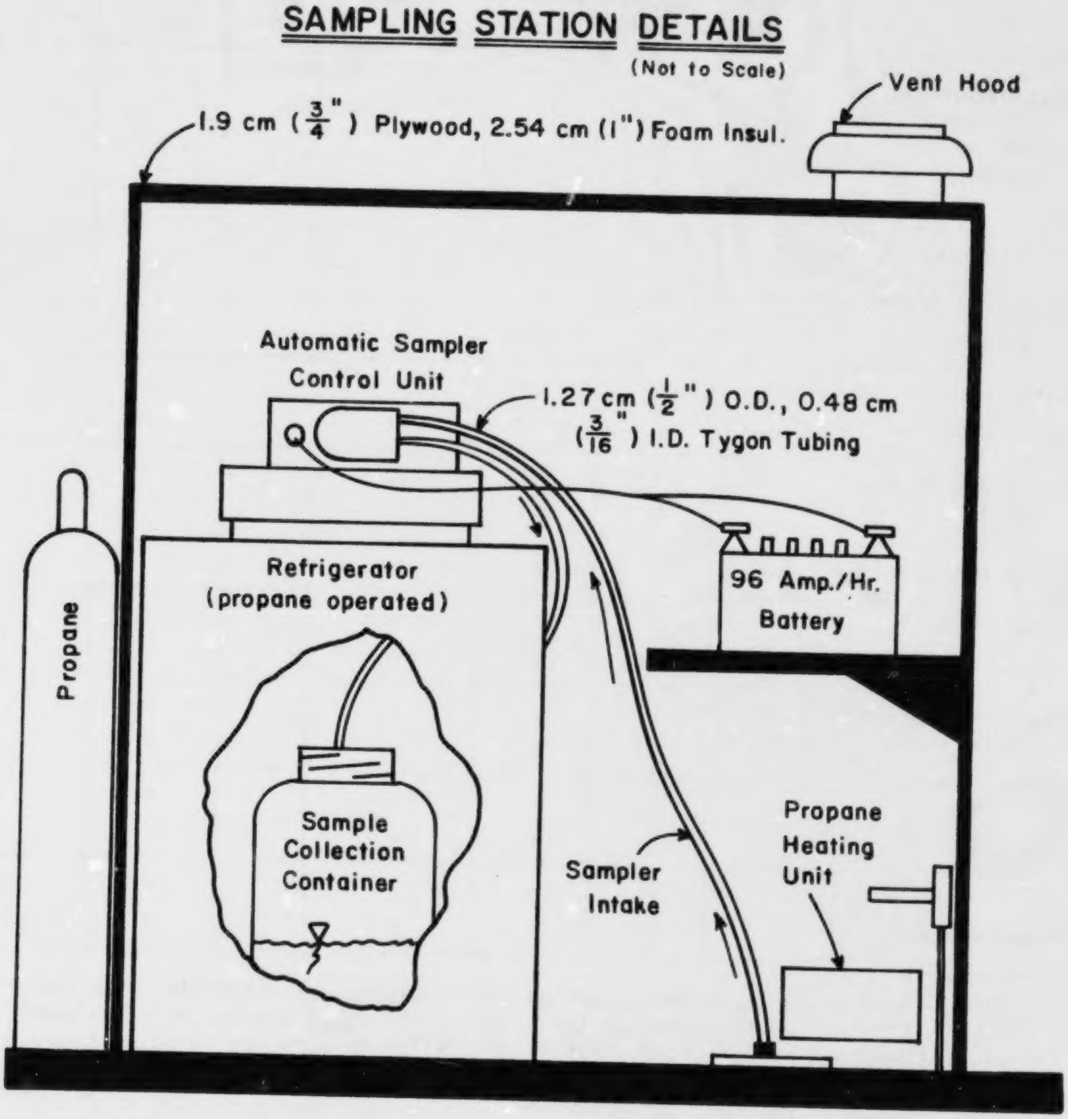
SAMPLING STATION DETAILS
(Not to Scale)
1.9 cm ($\frac{3}{4}$") Plywood, 2.54 cm (1") Foam Insul.
Vent Hood
Automatic Sampler Control Unit
1.27 cm ($\frac{1}{2}$") O.D., 0.48 cm ($\frac{3}{16}$") I.D. Tygon Tubing
Propane
Refrigerator (propane operated)
96 Amp./Hr. Battery
Sample Collection Container
Sampler Intake
Propane Heating Unit

Figure 5. Sampling station details.

SECTION 6

RESULTS AND DISCUSSION

GENERAL

Operation and maintenance records collected during the three visits at each site consist of observed procedures and the design or suggested mode of operation and maintenance. The major operational variances and the operator's reasons for the variances are presented. The chemical and biological parameters measured at each site are discussed on an individual basis. General trends are shown by plotting the parameter versus time for each of the three tours, and statistical comparisons are made to determine if differences between the tours and sites exist. comparisons of the three systems are based on parameters used to establish state and federal regulations, i.e., removal and effluent concentrations of Biochemical Oxygen Demand (BOD_5), and Suspended Solids (SS), Effluent Dissolved Oxygen concentration, and the pH value of the effluent.

The design of a typical intermittent sand filter system is based on the results of previous studies performed at Utah State University and the observations made during this study of actual applications of the basic system. Operation and maintenance requirements for the typical system are based on actual operating experiences observed during this study. Economic analyses are based on construction data from existing or planned intermittent sand filters in the continential United States.

OPERATION AND MAINTENANCE (O & M) AT MT. SHASTA, CALIFORNIA

Design O & M

Overall Facility O & M--

The operation and maintenance (O & M) of the aerated lagoon-intermittent sand filter system at Mt. Shasta is more complicated than the O & M at the other two sites because of the additional components of the system. The screen-comminutor, disinfection system, pumping system discharge to the subsurface water reclamation site (leach field), the Sacramento River outfall, and the aeration system, complicate the operation and maintenance.

Screening and comminution of the raw sewage is a continuous operation and twice daily cleaning of the bar screen to prevent blockage, and occasional lubrication of the comminutor is recommended.

Disinfection of the effluent is automatic after the initial start-up when monitoring of chlorine residuals and frequent adjustments are required. When a malfunction occurs, the system should be operated manually until repair or adjustments can be made. During summer operating conditions the effluent is discharged to a subsurface water reclamation site and disinfection is not required. As a precaution, however, the effluent is disinfected and sulfonated to remove the chlorine residual and prevent harmful effects on natural bacterial activity in the ground above and around the leach field. During winter operations, the discharge standards require disinfection with a maximum residual of 0.01 mg/l chlorine in the discharged water. Although not required by the discharge permit, the chlorinator and sulfonator are used throughout the year. The only unusual maintenance requirement for the chlorine contact basin is to remove accumulated solids. Because of the surges in the solids concentrations in the effluent immediately after introducing wastewater to the chlorine contact basin, it may be necessary to clean the basin more frequently. Both effluent discharge options described above are automatic and require little or no input by the operator. Normal summer operation requires that the effluent be pumped (automatic pumping station with two pumps) to the subsurface water reclamation site where it is automatically distributed over a leaching field. After an initial adjustment to evenly distribute the effluent over the leaching field, only an occasional adjustment is necessary to ensure proper operation. These adjustments consist of alternating the lead pump in service in the pump station and alternating discharge of effluent between the two leaching fields. The decision to switch to the other leaching field is to be based on information obtained by periodically inspecting the piezometers and test wells located throughout the system.

During the winter effluent is dishcarged by gravity directly into the Sacramento River. The outfall structure is to be inspected monthly and upstream and downstream river samples are to be analyzed for DO concentrations and pH values. Maintenance at the subsurface water reclamation site should consist primarily of brush removal around distribution boxes and test wells, and removal of blockages that may occur in the leach field pipes. This activity should require minimal time.

System O & M--

The lagoon system consists of four aerated lagoons with a surface area of eight acres and a capacity of 54,207 m^3 plus a ballast lagoon with a capacity of 20,820 m^3. The system is designed to produce an effluent treatable with the intermittent sand filters even in the event of a total failure of the aeration system. Aeration was provided to overcome the odor problems experienced in facultative lagoons during the spring and fall and to reduce the surface area required during the winter months.

During the summer the four aerated lagoons plus the ballast lagoon and dosing basin are used in series. The two primary aerated lagoons are operated at equal depths by alternating the discharge of raw wastewater into the two lagoons and by connecting the two lagoons with an overflow pipe. The alternate discharge of wastewater also prevents unequal sludge buildup in either lagoon. Effluent from the primary lagoons is collected in level control outlets enabling the operator to vary the lagoon water level. The water level in the two secondary lagoons is controlled with a valve located between the secondary and the ballast lagoon. Wastewater then flows from the ballast lagoon into the filter dosing basin at a rate dependent upon the discharge rate from the ballast lagoons. During the summer the lagoons are operated at "low level" or the water surface is 0.61 m below the top of the dike. Operating at the lower water level provides emergency storage, and during the warm months a higher biological activity is experienced and the low flow rates result in an increase in hydraulic residence time. Because of these factors, during the summer the lagoon system should produce an effluent quality equivalent or superior to the winter effluent quality even with a reduction in the volume of the lagoons.

A fixed volume of treated wastewater is discharged from the lagoon system each time that the intermittent sand filters are loaded. Discharge from the dosing basin is controlled with an electrically activated butterfly valve that is timer actuated. The water level in the dosing basin is lower by approximately 15 cm below the high water level with each dosing.

Only the four aerated lagoons are used during the winter and the water surface is maintained at the "high lagoon level" or 0.41 m from the top of the dike. The ballast lagoon and dosing basin are drained and used for emergency storage. The high lagoon level operation increases the volume of wastewater being aerated and extends the mean hydraulic residence to compensate for the decrease in efficiency due to low winter temperatures.

Maintenance of the lagoon system is relatively simple and is one of the major assets of lagoon systems. Although simple, inadequate attention can lead to problems. Exercising care in the following five areas of maintenance will prevent operational problems and extend the design service life of the system: scum control, weed control, odor control, mosquito control, and dike maintenance.

Three of the four available 7457 watt blowers are operated continuously to provide air to the four aerated lagoons. Operation of the blowers is scheduled so that each of the blowers is taken out of service periodically.

Each of the two major components of the aeration system require individual maintenance. Lubrication, inspection of alignment and intake air filter cleaning will assure good blower performance. The air distribution subsystem can become clogged from airborne particles and a crystalline deposit at the air-water interface causes progressive plugging of the diffuser ports. When the pressure in the lines exceeds 62,055 N/m^2, or even before it reaches this limit, an application of HCl gas at each of the eighteen cleaning ports is recommended to dissolve the deposits. Even if there is no increase in pressure, the diffuser tubes should be cleaned with HCl at least every three months.

Intermittent Sand Filters O & M--

The purpose of the intermittent sand filters is to protect the subsurface water reclamation site from solid deposits which could cause substantial damange and limit the service life. The filters are normally operated during the recreational season (May 1 - Oct 31) at which time the effluent is discharged to the subsurface water reclamation site. The filters can also be used during the winter if the lagoon effluent does not meet the discharge permit requirements of 30 mg/l of both BOD_5 and suspended solids.

Operation of the filters is based on using the underdrain system as a reservoir (946 m^3) of filtered water than can be released at a controlled rate to sustain a reasonably constant flow, preventing unnecessary surges in the disinfection system. However, it is important to keep the reservoir level below the bottom of the filter sand (at least 0.152 m below) to enable the sand to dry out and provide air to the organisms for biological digestion of the deposited organics. Deposits on the surface and those that penetrated the surface can be actively digested during the period between dosings when operated properly.

A tentative mode of operation suggested by the design engineer required that each filter receive two equal hydraulic loadings within a 24 hour period, and then the filter would not be loaded again until the filter had rested for two consecutive days. Electronic timers with automatic valves are available to operate the filters in sequence automatically. It was anticipated that various sequencing modes would be used during the first year of operation and the experience would lead to a satisfactory operational mode.

Maintenance of the filters consists of removing the solids that have accumulated on the surface of the filter media. The time between cleanings is dependent on quantity and quality of the water treated. Cleaning procedures suggested in the O & M manual recommended removal of the top 5.0 cm of media in work areas of 5.48 - 6.10 m in diameter. Due to the size of the filters, mechanical assistance under the supervision of the engineer could be used. Using a removal rate of 5.0 cm per cleaning and a minimum media operating depth of 51 cm, sand would have to be added every other cleaning. Replacement sand must meet the specifications used to select the original sand.

Other areas of filter maintenance are weed and rodent control on the filter surface and earthen retaining dikes, and back flushing the filter underdrains if plugging occurs.

Personnel Requirements--

The estimation of the manpower requirements reported in the O & M manual was made in accordance with the Environmental Protection Agency "Estimating Staffing for Municipal Wastewater Treatment Facilities" dated March 1974 (EPA, 1974).

Six major categories of work were selected, and the estimated time required in each category are presented in Table 7.

It was estimated that 2.4 man-years would be adequate to operate the facility. The facility is classified as a Class II plant by the State of California and requires an operator with a Grade II Certificate. A description of the manpower requirements on a weekday/weekend and nighttime operation basis is presented in the following paragraphs.

Weekday operation was to be carried out by the full time Grade II operator with a second operator with either Grade II, Grade I, or Operator-in-Training rating available for "two-man" operations. Weekend staffing required a daily visit by a Grade II operator to make necessary inspections and adjustments. Nighttime monitoring of plant operation is accomplished with a telemetry system that warns the Mt. Shasta police station of a problem. When the alarm sounds at the police station, the Grade II operator on call is notified.

The O & M manual recommended that the City of Mt. Shasta employ two Grade II operators and at least two Grade I operators, or Operators-in-Training, for back-up personnel. The only full-time employee was to be one of the Grade II operators.

Observed O & M

Overall Facility O & M--

The following observations were made during the first year and one half of operation after construction of the Mt. Shasta facility. Many items that are cited are the result of construction and design errors, equipment failure, operation errors due to lack of experience, and accidents.

TABLE 7. STAFFING ESTIMATE WORK SHEET (CITY OF MT. SHASTA, O & M MANUAL, TABLE VI-C-3)

Staffing Suggestion	Total Hours per Year	Number of Men*
Operation	1000	.7
Maintenance	802	.5
Supervision	550	.4
Clerical	73	.1
Laboratory	378	.3
Yardwork	550	.4
Totals	3353	2.4

*Assumes 1500 hours per year per man.

References to tour #1, 2, and 3 represent the three visits made to the facility. For the dates of the tours refer to the Methods and Procedures section.

The bar screen and comminutor operated without major incident except for once in the winter of 1978 when heavy rainfall caused an overflow of the headworks resulting in some erosion. In order to prevent a reoccurrence of the erosion, an asphaltic concrete collection basin and overflow pipe connected to one of the primary lagoons was constructed.

Although the disinfection system was designed to be fully automatic, during tours #1 and #2, it was troubled with several failures which in turn led to manual operations with adjustments and readjustments. Most of these failures were related to the loss of prime for the four sampling pumps designed to provide continuous sampling for the automatic chlorine residual analyzer and the SO_2 analyzer used in conjunction with the chlorination device. Prior to tour #3, the sampling pumps were relocated in a concrete vault adjacent to the chlorine contact basin and below the water level thus preventing loss of prime on the sampling pumps. A change in sampling location in the chlorine contact basin was also made to improve the sensitivity of the analyzers. These changes along with others mentioned later were responsible for a sampling period of only 15 days for tour #3. The chlorine contact basin was cleaned during the period of two weeks that the reconstruction of the chlorine system was taking place. During tour #3, the disinfection system operated without failure or problems, indicating the problem had been solved.

Tour #1--During tour #1 effluent was discharged directly to the Sacramento River outfall, and the system operated without incident for the full thirty day sampling period. The intermittent sand filters were being operated during this tour.

Tour #2--The subsurface water reclamation site was used during tour #2 and tour #3. At the beginning of tour #2, an accidental flooding of the pumping station occurred during an attempt to start up the system, but no major damage was suffered. Investigation revealed that small rocks, apparently in the outfall line, had held a valve open thus causing the flood as the contents of the two miles of outfall pipe drained into the pump station. After partial dismantling and drying of the pump station, the oil was changed in the two electric motors and the system was operational. The operator decided for safety purposes that a second manual valve be installed that would prevent a repeat of this type of accident. Thus, tour #2 was extended an additional 10 days awaiting the arrival of the valve and its installation. During the remainder of the summer operations, the pump station suffered several breakdowns, numerous blown gaskets and the complete rebuilding of one of the pumps was necessary.

Tour #3--The pump station was totally dismantled at the beginning of Tour #3 for replacement of parts and blown gaskets. Only one pump could be put back into operation, and it worked during the remainder of the sample period. Operation and maintenance at the subsurface water reclamation site were negligible during the two sample periods (Tour #2 and #3) when it was used.

Lagoon System O & M--

Tour #1--Upon arrival for the first sample period the lagoon system was in normal winter operation using the four aerated lagoons in series with the ballast lagoon and dosing basin idle, but not totally drained. The aeration system had caused various problems ranging from blower failure to excessively high pressure due to plugged diffuser lines. A Hinde Engineering representative and Contri Construction workers arrived during the first week to repunch holes into the aeration lines to reduce the pressure. Lowering the water level in each lagoon was required to gain access to the diffusion lines for the reperforation process. The lowering process decreased the lagoon efficiency greatly during the reperforation process.

While lowering the water level in lagoon #1 to accept the draw-off from lagoon #2, the bottom drain line broke due to water hammer when the valve accidently closed too rapidly. To avoid immediate dike erosion, the contents of lagoon #1 were drained into lagoon #4 including some sludge from the bottom of lagoon #1. Lagoon #1 was then out of service for the remaining sixteen days of sampling. Five days before the end of tour #1, lagoon #4 was drained to provide access to the broken drain from lagoon #1. The resulting operational mode for the lagoons consisted of aerated lagoon #2 discharging to aerated lagoon #3 and the effluent from #3 passing to the ballast lagoon.

Additional maintenance observed during tour #1 consisted of the gas treatment of the aeration system prior to the arrival of the Hinde Engineering representative.

Tour #2--During tour #2 the lagoons were in normal summer operational mode, using all four aerated lagoons with the ballast lagoon and dosing basin in series. The lagoon system was essentially trouble-free but prior to the arrival of the research team, the operation of the filters at high loading rates would draw the lagoons down to low levels. The lagoons would then refill without discharge while the filters drained and were cleaned or raked. This cycle required two to three weeks to complete. The results of this type of operation along with the erratic withdrawal rates from the lagoon system used during the parallel operation of the filters caused variations in the lagoon performance.

Lagoon maintenance during tour #2 consisted of cutting the grass around the entire operation.

Tour #3--Prior to this sampling period, heavy rains had damaged the dikes of lagoons #1 and #2, and this led to a failure in the lagoon #1 dike wall where the broken pipe had been repaired after tour #1. Because of the failure in the dike the aeration systems in lagoons #3 and #4 were not operated and lagoon #4 was not in service during the entire sampling period. The operational mode during tour #3 consisted of aerated lagoons #1 and #2 in series with lagoon #3 and the ballast lagoon. Hydraulic control during all three tours was always at the discretion of the operator who many times would adjust the flow at various points in the system and never record the changes.

Intermittent Sand Filters O & M--

Tour #1--Operation of the filters had been terminated one week prior to the beginning of sampling period #1 to allow the lagoons to refill after being drained to inspect the aeration lines. During the week of inactivity, there had been snow and rain and extremely cold temperatures. On the first day of operation the filters were 90 percent covered with snow and ice. It was apparent that the filters were frozen when the ice remained attached to the media surface during the dosing cycle, water levels receded slower than normal, and the effluent suspended solids were greater than that of the applied water. Closer inspection revealed that the top 3.81 cm of media of all three filters were frozen even after the snow and ice melted away. The only remedy was to let the warming daily temperatures thaw the filters.

The operational mode was set up by the operator with the intention of supplying a constant flowrate to the disinfection system.

Intermittent sand filters No. 1 and 2 were in operation simultaneously, with each filter receiving water twice daily and the sequencing was set to provide four daily doses, alternating from Filter No. 1 to Filter No. 2 and then back again to Filter No. 1.

Each filter received twelve hours of rest between loadings. With the filters frozen, this type of operation resulted in flooding of the filters and filter influent infiltrating between the filter side walls and frozen sand filter bed (i.e., short circuiting). This operational mode was continued through the entire first sampling period. Dosing of the filters was stopped for a 24-hour period during which lagoon #4 received the discharge from lagoon #1 through the broken #1 bottom drain. This was done to prevent high concentrations of solids from being applied to the filters.

There was no observed maintenance performed on the filters during this tour.

Tour #2--Upon returning to Mt. Shasta, it was observed that on the average 20.3-25.4 cm of sand had been removed in two cleaning operations with no replacement of the sand. Heavy equipment such as a road grader, front-end loader and dump trucks were used in the first crude attempt to clean the filters. The second cleaning was reportedly much more refined. The unfortunate result was that the media depth was less than the 50.8 cm minimum in some locations.

Operation of the filters during the second sampling period started out as a slow sand filter under direction of the operator for purposes of obtaining a better organic mat on the filter surface, better effluent quality, and a continuous high discharge rate to use the pumping station more efficiently by minimizing on-off type of operation. The slow sand filter operation consisted of allowing the lagoons to fill to the "lagoon high level" without any daily discharge. Once the lagoons were filled, the filter loading sequence was set for dosing five minutes every two hours on a single filter. this loading schedule provided a constant head ranging from 0.30 m in the beginning, to 0.6 m at the top of the concrete block wall when the head on the filter indicated slow passage of water. The passage of water through the filter usually began to slow down during the second day of operation. Discharge rates during this operation were in the range of 3028-3785 m^3/d. This operation was continued until the lagoons reached "lagoon low level" or the filter was plugged. After about two weeks of this type of operation, the operator indicated the filter would plug.

Short filter run time along with the long period of time required for the filters to drain and dry to enable cleaning operations to commence was the main problem with this type of operation. The use of a relatively large constant head above the filters also caused deeper penetration of organic material into the filter media requiring more than normal sand removal during cleanings. This practice also resulted in a progressive shortening of each run time because of the greater penetration of the solids.

Four filter sections each approximately 0.2 hectare in size were operated in parallel with one operating as a slow sand filter and the remaining three operating as an intermittent sand filter. The intermittent sand filter systems received two equal doses of 473 m^3 daily. The intermittent sand filters received two days of rest after each day of loading. The operational scheme is shown in Figure 6.

The intermittent sand filters were loaded at a hydraulic loading rate of 4680 $m^3/ha \cdot d$. The slow filter loading sequence was the same as described earlier only with the water applied to one half of a filter every four hours for five minutes at a loading rate of 9360 $m^3/ha \cdot d$.

Separation of the effluents in a common collection manifold was accomplished by installing four 0.305 m diameter plugs adapted with flow restriction and separation devices in the filter section drain line as shown in Figure 7.

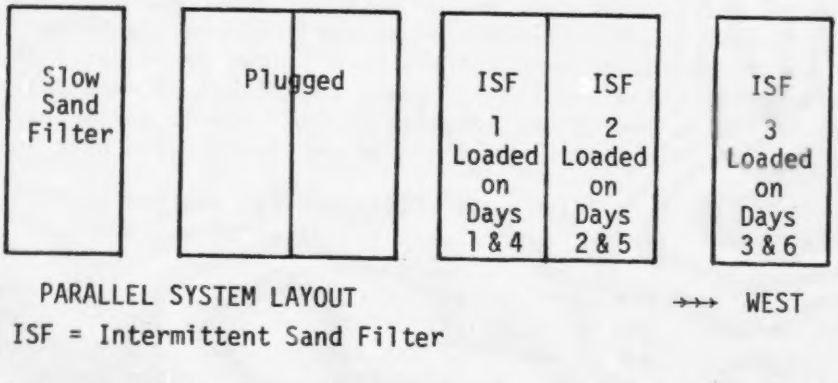
Slow Sand Filter
Plugged
ISF 1 Loaded on Days 1 & 4
ISF 2 Loaded on Days 2 & 5
ISF 3 Loaded on Days 3 & 6
PARALLEL SYSTEM LAYOUT
→→→ WEST
ISF = Intermittent Sand Filter

Figure 6. Operational scheme during parallel operation of slow and intermittent sand filters.

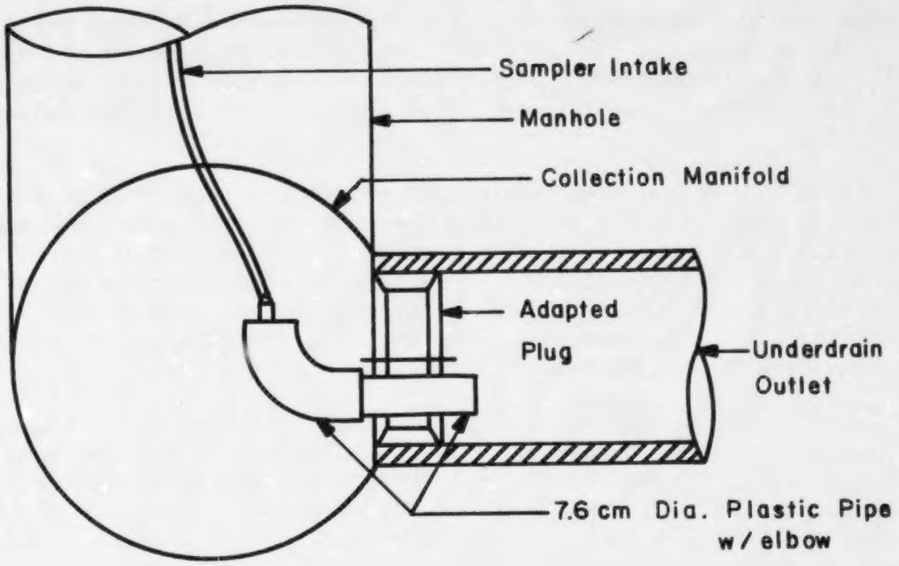

Figure 7. Arrangement of adapted plug to facilitate sample collection.

The flow restriction was used to prevent surges in the disinfection system and provided a constant flow rate from the two filter systems.

Five days after the slow and intermittent sand filters were simultaneously put into service, the slow sand filter was plugged and had filtered approximately 7571 m^3 of wastewater.

The intermittent sand filters provided good service throughout the 30-day sample period with only slight evidence of plugging in low areas and areas closest to the distribution splash pads where puddles formed. Although the intermittent sand filters were loaded every third day and at lower loading rate than the slow filters, each 0.202 hectare filter treated over 7571 m^3 during the 30-day sampling period without any maintenance, and it appeared that maintenance would not be required in the near future.

A second run of the slow sand filter system resulted in five days of service, again treating approximately 7571 m^3 of wastewater.

Maintenance on the previously plugged slow filter and the other plugged filter was accomplished using a utility tractor and a landscape rake six feet in width. The rake penetrated the sand surface to a depth of 6.4 cm. One hour was required to rake a section. One tractor operator and one man adjusting the depth of the rake were required. This was the only maintenance observed during tour #2.

Tour #3--At the conclusion of the filter operation in the Fall of 1977, the filters were scarified with a roto-tiller type mixer down to a depth of 20.3 cm below the surface without any surface cleaning or sand removal. During the period of rest an above-normal rain and snow fall left the filter surface very loose, and when walking on the sand surface a foot impression 7.6 to 15.2 cm in depth was made.

The filter loading sequence was initially set-up to load a filter with four one-hour doses daily with two days to rest before reloading. This operational mode was similar to that suggested by the design engineer except for the number of loadings, which resulted in overflowing of the filters and flooding the entire filter system. Water in the underdrain manholes was at the level of the water on the surface of the filters. The water level was 0.61 m above the surface of the sand. During this period of overloading the effluent discharge rate from the system was approximately 4164 m^3/d. The reason given by the operator for this overloading was to reduce the level of water in the lagoons to provide some emergency holding capacity. After draining the filters, a normal loading time of 10-15 minutes was used instead of the loading time of one hour used during the overloading period. A loading period of 10-15 minutes continued through the remainder of the sampling period.

Twelve days after the start-up with the loosened sand and high hydraulic loading rate, one of the three filters plugged. The cause of such a relatively short operating period could be attributed to the lack of cleaning prior to the scarifying, which mixed the surface organic concentration throughout the top 20-25 cm of sand. Also the loose condition of the filter surface would increase the depth of penetration of solids into the filter media.

Beyond the maintenance performed at the end of the filter operation in 1977, no other maintenance was observed during the third sample period.

A major modification of the automatic dosing valves was performed to prevent flooding of the electrical components by putting a 1.52 m extension on the valves, thus placing the electronics above ground.

Personnel Requirements--

During the first two sample periods, operation and maintenance was carried out by one full time Grade II operator with the assistance of the back-up Grade II operator whenever it was required. Prior to the third tour the city provided a full time operator in training to assist the full time operator in addition to the back-up Grade II operator.

OPERATION AND MAINTENANCE (O & M) AT MORIARTY, NEW MEXICO

Design O & M

Overall Facility O & M--

The operation of the Moriarty facility was designed to be automatic after the initial start-up with minor changes to be made to accommodate periodic variations in the influent characteristics.

Flat topography dictated the use of a lift station at the entrance of the plant consisting of two screw pumps each with a maximum capacity of 1514 m^3/d. Both pumps are equipped with an automatic lubrication device. The control system was designed to allow alternations between each pump as the lead pump with the remaining pump as the back-up unit. This alternation must be monitored by the operator to ensure equal operation time for each pump. Routine lubrication inspection and washing of the screw pumps is necessary to prevent failure and unpleasant odors. After the initial pumping of the raw sewage, gravity supplies the remaining energy to move the water through the system.

Screening and comminution equipment requires daily cleaning and inspection. If a malfunction or power failure occurs in the comminutor, the wastewater is directed to the bar screen by-pass.

Disinfection is accomplished with four tablet type chlorinators. Operation of the chlorinators is on a trial and error basis, dependent on discharge flowrate and chlorine demand of the discharged water. Each chlorinator will hold up to four columns of chlorine tablets, and three different discharge weirs provide numerous combinations to control the chlorine residual. The O & M manual recommends that chlorine residual and fecal coliform tests be performed after every trial and error sequence and that the results be recorded for future reference. Contact time is provided in the combination dosing basin and chlorine contact chamber.

After determining the most economical chlorine residual, only periodic chlorine tablet addition, chlorinator cleaning, and a routine check on the chlorine residual is required.

Lagoon System O & M--

The lagoon system consists of two aerated lagoons and two polishing ponds with each of the lagoons having a capacity of 3785 m^3.

Normal operation of the two aerated lagoons as described in the O & M manual suggests series operation to provide a hydraulic residence time of ten days at a design flow of 757 m^3/d. A flow splitter box at the entrance to the aerated lagoons enables the operator to choose the order in which the lagoons operate in series to prevent excessive sludge build up in either lagoon. Another option is to operate the two aerated lagoons in parallel. The operating depth in both aerated lagoons is 3.05 m. The option to vary the depth does not exist.

Aeration of each lagoon is accomplished with a ten horsepower mechanical mixer in each basin. The aerators are controlled by timers with multiple variations of 15 minute aeration intervals. The aerators are designed to provide adequate gas transfer to the lagoons to sustain a minimum of 2.0 mg/l dissolved oxygen (DO). To achieve the desired economic minimum of 2.0 mg/l DO, a trial and error approach is recommended in the O & M manual to determine the number of 15-minute cycles necessary. The manual also recommends that a written record of the laboratory analyses and corresponding timer settings be maintained for future reference. Variations in aeration requirements will result from seasonal changes in sewage characteristics caused by the summer tourist season or school being in session.

Maintenance of the aerated lagoons primarily consists of lubricating the aerators and removing floating debris and scum. The aerated lagoon effluent is collected in a flow splitter box that has two options for operation. The first and normal operational mode requires the equal distribution of the series aerated lagoon effluent to the two polishing ponds. The second corresponds to the possible future use of the two aerated lagoons as parallel systems in which case the two polishing ponds would receive separate discharges from the two aerated lagoons creating two parallel systems.

The constant operating depth for the polishing ponds is 0.91 m and the 3785 m^3 capacity at this depth provides ten additional days of detention when operated in series. Concrete aprons are provided on the interior of all lagoon dikes making the maintenance requirements minimal. The only anticipated maintenance on the dikes is the repair of cracks in the concrete.

Intermittent Sand Filters O & M--

The polishing pond effluent passes through the chlorinators and accumulates in the combination chlorine contact chamber and dosing basin. The contact basin is equipped with an automatic dosing siphon that delivers the accumulated volume of 94.6 m^3 to the filters.

As described above the intermittent sand filters are loaded automatically and the rate of application of wastewater fluctuates with the discharge from the lagoon system. Normal operation at design flow of 757 m^3/d would provide eight doses per day to four of the eight 18.3 m x 18.3 m square filter units at a hydraulic loading rate of 5,651 $m^3/ha \cdot d$. Winter operation requires bypassing the filters if freezing of the filters occurs.

Replication of filters was provided so that the first set of filters could be taken out of service and dried, raked or cleaned. Switching filters is done manually using the valves located in the distribution system. Filter effluent is piped to a dry stream bed, a short distance from the filters where it evaporates and seeps into the ground. Raking of the surface to a depth of 2.5 to 5.0 cm loosens the accumulated solids, and an occasional raking of the surface of intermittent sand filters prolongs the filter run.

Personnel Requirements--

Annual manpower requirements for the operation and maintenance of the Moriarty wastewater treatment facility was estimated to be about one man year. One Class II certified operator was recommended with support from other city personnel, including one helper as the back-up operator. Both men were to be familiar with the operation and maintenance of all components in the facility. The operator was to be responsible for all records and supervision of operation and maintenance.

Observed O & M

Overall Facility O & M--

The automatic operation of the Moriarty wastewater treatment facility was observed for three sampling periods with no major problem occurring in the normal operational mode. Preliminary adjustments to the system had been completed prior to the first sampling period, and only monitoring and maintenance was required during the initial tour.

Observed maintenance requirements for the overall system consisted of routine facility inspections and lubrication of the aerators. Good housekeeping activities included routine washing of the screw pumps and comminuter, along with weed control around the grounds. The disinfection system required daily monitoring of the chlorine and the chlorine residual in the effluent from the contact basin.

Lagoon System O & M--

The switching of the order of application of wastewater to the aerated lagoons in series was arbitrarily chosen by the operator with no apparent schedule. Aerator sequencing was initially set for one 15-minute aeration interval for every hour in each of the lagoons. There was no change in aeration sequencing observed during the three tours. Although changes may have been initiated between the sampling periods, information regarding the changes was not available.

Several times during the three sampling periods, a growth of Daphnia sp. was observed. During these periods, lagoon performance decreased as the Daphnia sp. population flourished. These periods of Daphnia sp. growth usually only lasted 2 to 3 days, but the lagoon performance did not recover for about one week after the decline in population.

Lagoon system maintenance primarily consisted of weed control around the outside of the lagoon dike. The inside dikes were covered with concrete aprons and were essentially maintenance free. An unexpected maintenance requirement was the cleaning of calcium carbonate crystalline formations from the polishing pond outlets. The formation of calcium carbonate crystals caused by the high hardness and alkalinity of the local water supply and the alkaline environment of the lagoons would progressively plug the 15.2 cm diameter outlet pipes.

Intermittent Sand Filters O & M--

Tour #1--Prior to the beginning of the first sampling period, the dosing siphon had been leaking and the volume of each dose would vary. The cause of the malfunction was unknown. A constant volume of wastewater was discharged only after the operator cleaned the entire dosing basin and dismantled and cleaned the dosing siphon. Unfortunately, this cleaning did not take place until four days prior to the end of Tour #1.

Although the dosing siphon was not operating properly, the hydraulic loading rate was not affected because it is dependent upon the total volume of wastewater applied to the filter. The only effect was the reduction in rest time between dosings.

Operation of the filters was set up to use two filters at a time supplying 0.067 hectare of surface area. The intended operation required the two filters in operation to remain in use until they became plugged at which time another set would be put into service, and so on, until all eight filters were used. This provided adequate time to clean the plugged filters and retur them to service.

Application of an average daily flow of 151 m^3/d resulted in an operating hydraulic loading rate of 2246 $m^3/ha \cdot d$. Loading would be intermittent depending on the dosing siphon cycle which at 151 m^3/d would be less than twice a day for the normal 94.6 m^3 dose. With the dosing siphon malfunction, it was dosing approximately three times a day.

The two initial filters were in operation for about two months before plugging. Plugging occurred two days after the start of sampling period #1. The operator switched to the next set of filters which operated for 26 continuous days before plugging. The flow was then directed to the next set of filters that provided service for only five days before plugging.

The decreasing period of time between filter pluggings on these new filters was primarily caused by two factors. The first and probably most important was the wind blown local soil that accumulated on the surface of the filters. The soil contains a high percentage of clay, and when exposed to the wastewater, the clay would expand and partially plug the filters. Depending upon the amount of wind blown soil present, the run time would decrease accordingly.

The second factor was calcium carbonate precipitation on the filter surface. Calcium carbonate precipitation was attributable to the total hardness of greater than 500 mg/l as $CaCO_3$ and the alkalinity of greater than 400 mg/l as $CaCO_3$ reacting with the chlorine compounds and the influence of the high pH values frequently observed in the lagoon effluents. Within an hour after dosing, patches of white colored precipitate could be observed on the filter surface. As the rate of filtration decreased, more precipitant would be formed because of the growth of algae in the water standing on the surface of the filters. A white cement-like crust was observed on the dry filter surface, and it was highly impermeable when water was applied.

Observed maintenance to the filter system during sampling period #1 consisted of cleaning the dosing basin and dosing siphon. This maintenance required two man-hours. Also, one filter section was raked requiring one man-hour.

Tours #2 and #3--Upon arrival at the Moriarty facility for the second sampling period, the eight filters were plugged and the filter system was being bypassed. Between tour #1 and tour #2, the filter system had been plagued with repeated plugging resulting from the two factors cited during tour #1 (i.e.: wind blow soil and calcium carbonate precipitation).

The operator had raked all but one filter section at least once with no apparent improvement in filter service life. Cleaning operations were apparently restricted to areas where green algal concentrations were located. The abundance of operational problems had caused a discouraged attitude toward refurbishing the filter system.

After cleaning all eight filters, a new operational mode was put into effect. Two filters were in operation simultaneously as before, except the filters were loaded for one day then left idle for three days while the remaining six filters were dosed once daily. The effect of this operational change was to divide the hydraulic loading rate by four to produce an average hydraulic loading rate of 749 $m^3/ha \cdot d$. This operational mode provided more time for the filters to drain. Rest periods between doses have been shown to extend the operating period between cleanings. In addition to the new mode of operation of the filters, disinfected effluent was applied to only two of the four filter groups for the duration of the second sampling period. Disinfection was eliminated to evaluate the need for chlorination to produce satisfactory effluent fecal coliform concentrations and to evaluate the effects of pre-chlorination on filter performance.

Since the dosing siphon cycle is dependent on the flow rate, the operator alternated the applications of wastewater to the filters by manually adjusting valves after two dosings on a filter. The filters were loaded with approximately 189 m^3 of wastewater each day. This operational mode was continued throughout tours #2 and #3. It was anticipated that this operational mode would continue until an increase in flow dictated an operational change.

Maintenance to the filter system prior to the major cleaning operation was estimated to be seven man-hours for raking the seven filters. Before cleaning the filters with a small tractor equipped with a blade, the redwood distribution channels were removed. It was decided to replace the distribution channels with gravel splash pads because of the poor performance of the channels and to facilitate mechanical cleaning operations in the future. A 11,185 watt, two cylinder diesel tractor equipped with a hydraulic operated, front mounted, one-sixth cubic yard (0.22 m^3) bucket loader and rear mounted landscape scraper was rented at $60 a day plus tax. An itemized listing of the man-hours and machine hours required to clean the filters is shown in Table 8.

Maintenance to the filters, following the major cleaning, was performed using a homemade three foot wide filter rake requiring two people to pull it around the filters. During the time between the major cleaning and the end of sampling period #3, the operator and co-operator raked six of the eight filters. The raking operation requires approximately one half hour for each filter section.

Personnel Requirements--

The operator was also the director of public works for the City of Moriarty. He made four daily inspection visits to the wastewater treatment facility requiring 10-15 minutes each visit. The co-operator on occasion made the inspection visits in the absence of the operator. The only observed laboratory work was the monitoring of the chlorine residual. Most operational and maintenance work was performed by the operator with the help of other city personnel when required.

TABLE 8. SUMMARY OF THE MORIARTY FILTER CLEANING OPERATION REQUIREMENTS FOR EIGHT SQUARE FILTER SECTIONS TOTALING 0.27 HECTARE

Activity	Manhours	Machine Hours
Distribution channel removal	8 (2 people)	4
Filter scraping and sand removal	12	12
Floating sand surface	4	4
Manual cleaning of filter edges	4	-
Obtaining gravel from Albuquerque, N.M.	5 (2 loads, 4.4 tons)[a]	-
Placement of gravel splash pads	4	-
Total hours	37	20 (3 days rental)

[a] 1 ton = 907 kilograms.

OPERATION AND MAINTENANCE (O & M) AT AILEY, GEORGIA

Design O & M

Overall Facility--

One of the main elements of the design of this system was the ease of operation and maintenance. After the initial start-up, the entire system was designed to be free of operational requirements except for minor seasonal changes. Winter operational variations include recirculation of effluent from the oxidation pond to improve the performance during the cold months. Summer operational variations include the option to restrict discharge of effluent to the receiving stream when the flow in the stream is inadequate to prove the dilution specified in the discharge permit. Design storage capacity in the lagoons is adequate to provide approximately 33 days of retention without discharge.

Operation of the disinfection system is fully automatic after the initial adjustments. The system is electronically interconnected to a discharge flow-rate measuring device that automatically controls chlorine release for disinfection of the discharged water. Daily monitoring of the chlorine residual is recommended in the O & M manual to check operation of the disinfection system.

Maintenance of the system requires occasional weed removal and inspection of the chlorine contact chamber, along with periodic inspection and replacement of empty chlorine gas tanks.

Lagoon System O & M--

The lagoon system consists of a two-cell 2.2 hectare oxidation pond with a flow splitter at the discharge and a 0.30 hectare polishing pond. Normally both of those lagoons are operated at a depth of 1.1 m.

The topography of the system necessitated the use of lift stations at the influent and effluent of the oxidation pond. These lift stations are completely automatic and only require periodic lubrication and cleaning of the automatic controls.

The 2.2 hectare oxidation pond has a baffle wall constructed at the two thirds point between the influent and effluent to prevent short circuiting, to retain the majority of the settleable solids in the first two thirds, and to prevent scum and grease from reaching the multi-level outlet structure. The multi-level outlet structure enables the operator to select the best level of withdrawal from the lagoon.

The flow splitter located at the discharge end of the oxidation pond allows the operator to recirculate the oxidation pond effluent when the treatment efficiency is decreased by either low temperatures or increased flowrates caused by heavy precipitation during the winter season. Operation of the flow splitter is at the discretion of the operator and is to be employed to improve performance of the system.

Variations from the normal operating depth in the polishing pond are used to retain effluent, and the depth can be increased to 1.5 m. It is recommended that discharge at the end of a storage period be carefully monitored to prevent over-loading of the filters and the disinfection system. The multi-level outlet structure from the polishing pond provides the option to withdraw water from various lagoon depths to obtain optimum effluent quality for application to the intermittent sand filters.

Maintenance of the lagoon system is greatly reduced by the construction of the concrete aprons completely surrounding both lagoons. Routine inspection of the apron and other lagoon structures to locate and immediatly repair damage is recommended to prolong the life of the system. The apron reduces the problem of aquatic weeds and grass encroachment in the lagoons. Cutting the grass to improve the appearance and the control of aquatic weeds within the pond should be practiced on a rountine basis. The apron also reduces the problem of insect control by eliminating the growth of grass and weeds in the shallow waters.

Scum control is to be accomplished by mixing the water with a small boat equipped with an outboard motor. If scum does not disappear in a few days, a skimming operation should be undertaken.

It is recommended that sludge deposits in the main section of the oxidation pond be removed approximately every five years by either pumping or dredging. Those deposits should be disposed of properly in landfills or other methods to protect public health and safety.

Intermittent Sand Filters O & M--

Operation of the intermittent sand filters is automatically controlled by the discharge flow rate from the polishing pond. Polishing pond effluent flows into a dosing basin that collects and distributes approximately 68 m^3 to the intermittent sand filters each time it fills. Electronic floats connected to a control system with two electric valves alternate loadings automatically between the two sand filters. The number of dosings per day is dependent upon the discharge from the lagoon system. The design hydraulic loading rate of 3744 $m^3/ha \cdot d$ is applied to the filters in six dosings per day or a total of 416 m^3/d. Normal design flow rates of 303 m^3/d would produce a hydraulic loading rate of 2808 $m^3/ha \cdot d$ with 4.5 doses per day. Manual manipulation of the dosing cycle is possible in the event of power failure or an operational emergency.

The volume of water is distributed to the sand surface through the distribution manifold by gravity. Once applied to the filter the water passes to the underdrains system and then through a flow control ballcentric plug valve to the disinfection system. The filtered water is temporarily stored in the filter underdrain while it is released into the disinfection system at a controlled rate of 0.68 m^3/min to provide a mean hydraulic residence time of 30 minutes.

The requirement that the discharge rate not exceed a one to one ratio with the flow in the receiving stream can also be regulated using the throttling valve in conjunction with the discharge flowmeter and the Parshall flume installed in the stream bed.

Maintenance to the dosing basin consists of occasional lubrication of the electrically operated valves and the removal of floating debris from the surface of the water.

Recommended filter maintenance consists of observing the condition of the distribution system, the concrete retaining walls and the cleaning of the filters.

Weekly inspection of the surface condition of the sand and observation of the time required for the water to drain through the sand indicate when the filters require raking or cleaning. Inspection and removal of plant growth on the sand surface is equally important. The relatively small surface area of the filters and the fixed distribution system require that raking and cleaning procedures be manual.

Personnel Requirements--

Operation of the sewage treatment system and managerial responsibility lies with the Utilities Superintendent/Plant Operator. Aside from operations and routine maintenance, the supervision of the work force sufficient to handle the more physically demanding maintenance jobs is also his responsibility. An automatic alarm and warning system informs the operator or other responsible personnel by telephone of failure or stoppage of the two pumping stations. Essentially 24-hour monitoring of the facility is provided by the electronic warning system.

Observed O & M

Overall Facility O & M--

Tour #1--Overall system operation during the first sampling period was observed as being as described in the operation and maintenance manual. All systems were under full automatic operation. The lagoon system was at normal operating depth of 1.1 m with no recirculation during the entire 30 days of sampling.

The dry spring produced a progressively decreasing flow through the treatment plant. Loading on the filters ranged from over 416 m^3/d in the beginning to 151 m^3/d near the end of the sampling period. As a result of the decrease in flow, the hydraulic loading rate on the filters was automatically decreased.

Operation and maintenance of the Ailey sewage treatment plant during the first tour was at a minimum. Observed maintenance during this period involved raking of areas of the filters exhibiting wet green patches of algal growths. Releveling of the filter surface was required to eliminate original unequal distribution of the sand and scouring caused by the water distribution system. These activities required four man-hours to complete.

Tour #2--During the second sampling period, the system was not in the normal operating mode. The primary variation was caused by a failure in an underground electric line between the control building and the floats in the dosing basin, a week prior to the sampling period. All parts of the system were operating automatically except the dosing of the filters. The flow rate during this sampling period averaged 114 m^3/d. Therefore, one manual dose daily plus some overflow was adequate to process the lagoon discharge. After the first 12 days of sampling, the electricians repaired the malfunction and the dosing operation was returned to automatic operation.

Operation of the oxidation pond had been changed so that approximately one-half the discharge was being recirculated in an attempt to control the algal population and the algal mat on the surface of the oxidation pond. The operating depth for both lagoons was still at the normal operating depth of 1.1 m.

Maintenance performed on the system between tour #1 and tour #2 consisted of removing Bermuda grass from the surface of the filters twice, requiring 20 man-hours; mowing the grass on the facility grounds twice, requiring 28 man-hours; and raking one of the sand filters to eliminate ponding on the surface, requiring four man-hours. During the second sampling period, the only maintenance observed was the repair of the electrical failure.

Tour #3--The wet winter season produced high discharge rates from the treatment system ranging from 227 m^3/d to 568 m^3/d. High discharge rates affected the entire system, and it was necessary to increase the polishing pond level to decrease the loading on the intermittent sand filters. The water surface elevation in the polishing pond was increased gradually in two 2.54 cm increments as specified in the operation and maintenance manual.

During tour #3, loading of the filters was at a much higher rate than experienced before, and a continuous discharge from the filter underdrains was present. The throttling valve in the filter effluent line was responsible for the continuous discharge. Although the wet weather produced high flowrates in the system, automatic operation with a small modification in the polishing pond water level provided trouble-free service.

There was no observed maintenance performed or required during the third tour. Because of the high hydraulic loadings on the filters, it was necessary to rake the filter surfaces at the conclusion of the third sampling period.

Personnel Requirements--

The Utilities Superintendent/Plant Operator is the principal individual involved in the operation and maintenance of the facility. The system is inspected once each day except on weekends by the operator, and he determines the chlorine residual in the effluent and inspects the flow rate recorder in addition to a general inspection of the facility. This routine requires approximately one half hour each day.

SUMMARY OF O & M AT THE THREE SITES

A common objective in the design and operation of the three sites was to produce an effective means of treatment with a minimum of operation and maintenance. All three facilities were designed with automatic operation as the main objective excluding the initial start-up and beginning operating experiences that would eventually support the automatic operating mode. The amount of experience required varies with the complexity of the system. Tables 9 and 10 present a summary of the operating modes for normal operation, operational variations, and observed operations during the three sampling periods at each site for lagoon system operation and intermittent sand filter operation.

Observed operations at the Mt. Shasta facility were the most varied of the three sites. During each sampling period, different operations were either imposed by the operator or by a failure in part of the system. The primary variation was in the operation of the intermittent sand filters. Hydraulic loading rates could be varied at the Mt. Shasta facility and this was the most frequent variation observed. This system is the largest and most complex of the three sampling sites, and it was designed to operate automatically. The automatic operation is dependent upon establishing a basic operational mode as described in the O & M manual and making slight adjustments to the system to accommodate the most frequent changes, such as flowrate. Many problems occurred at the Mt. Shasta facility, but problems occur at all treatment systems. The best recourse is to solve the problem using common sense and maintaining the basic operating mode. This approach was not followed at Mt. Shasta. Constant changing and experimentation was common and led to frustration and inevitably failure.

The observed operations at the Moriarty, N.M., facility conformed with the design automatic operating mode, excluding the dosing siphon malfunction. Although the operation of the filters was a slight variation from the design

TABLE 9. SUMMARY OF INTERMITTENT SAND FILTER OPERATION

Operation Category	Mt. Shasta, California Water Pollution Control Facility	Moriarty, New Mexico Wastewater Treatment Facility	Ailey, Georgia Sewage Treatment Plant
Filter System Normal Operation	Normal operation (May 1 to Oct 31) Timer controlled automatic dosing. Hydraulic loading rate variable. Filter cycling--1 day load and 2 days rest.	Automatic dosing of four filters with dosing siphon. Hydraulic loading rates dependent on discharge rate from lagoon system, disinfection prior to filtration.	Automatic alternate dosing of the two filters. Hydraulic loading rate is dependent on lagoon discharge rate.
Operational Variations	Filters to be used in the winter only when the lagoon effluent doesn't meet discharge requirements.	During extremely cold weather when filter freezing can occur filters should be bypassed.	During dry weather, filter operation is restricted to ratio of 1 to 1 relative to discharge rate and stream flowrate.
Tour #1	Simultaneous use of two filters with 4 doses per day per filter providing 6 hours rest between doses. Problems: frozen filters, high hydraulic loading.	Dosing siphon malfunction resulted in unequal dosing cycles. Use of two filters simultaneously. Problems: short run time.	Normal operation.
Tour #2	Parallel systems, slow sand and intermittent sand filter operation. Problems: excessive sand removal during cleaning.	Dosing siphon functioning properly. Manual alternating of two filters simultaneously resulting in reduction of loading rate.	Malfunction in automatic dosing device resulted in manual dosing part of the tour. Normal operation resumed upon repair.
Tour #3	Four daily doses per filter, filter cycling 1 day load and 2 days rest. Problems: excessive loading, poor filter condition due to mixing of top 20-25 cm of sand.	Same as Tour #2, using all eight filter sections provides one day loaded and three days rest for each filter group.	Normal operation. Problems: high loading rates.
Comments	20-25 cm of sand removed in two cleanings. Filter loading to provide constant flow to disinfection system.	Problems: short service life due to wind blown soil layer, calcium carbonate precipitation.	System performed without major incident.

TABLE 10. SUMMARY OF LAGOON OPERATION

Operational Category	Mt. Shasta, California Water Pollution Control Facility	Moriarty, New Mexico Wastewater Treatment Facility	Ailey, Georgia Sewage Treatment Plant
Lagoon System Normal Operation	Summer operation. Aerated lagoons in series with ballast lagoon, operating at "lagoon high level," energency storage up to "lagoon high level".	Operation of aerated lagoons in series, polishing ponds in parallel. Aerators set to provide minimum of 2.0 mg/ℓ DO.	Normal operation: lagoons at normal operating depth of 1.1 m, no recirculation of oxidation pond effluent.
Operational Variations	Winter operation. Aerated lagoons in series with ballast lagoon drained, operating at "lagoon high level", storage in ballast lagoon.	Future operation of aerated lagoons and polishing ponds in two parallel systems. Aerators set for 2.0 mg/ℓ DO.	Dry weather operation: polishing pond depth increased for storage, oxidation pond not recirculated.
Tour #1	Aerated lagoons in series, operating at "lagoon high level", ballast lagoon inactive. Problems: Aeration system	Aerated lagoons in series, polishing ponds in parallel, Aerators set to operate for 15 minutes every hour.	Normal operating depth in both lagoons with no recirculation of the oxidation pond effluent.
Tour #2	Aerated lagoons in series with ballast lagoon, operating at "lagoon high level". Problems: none.	Same as Tour #1	Normal operating depths in both lagoons with recirculation of one-half of the oxidation pond effluent.
Tour #3	Aerated lagoons in series with ballast lagoon, operating at "lagoon low level". Problems: aeration and lagoon #4 out of service.	Same as Tour #1.	Increased depth in polishing pond, oxidation pond at normal depth with no recirculation.
Comments	Aeration system source of problems, lagoon level changes by operator.	Problems: calcium carbonate crystalization in polishing pond outlet pipe causes plugging.	During tour #3 wet weather necessitates the storage of some water to prevent the overloading of the filters.

operation, it was justified by the small flow rate the facility was handling. The variations implemented prior to the sampling period during tour #2 improved the performance and required more daily manual input into the system, but the overall manpower requirements were not affected. Excluding the loss of automatic operation, little impact on the system was observed and the hydraulic loading rate on the filter system was reduced and the service life of the filters extended.

The Ailey system was operated within the design operating mode with great success. The only variations that were observed were oxidation pond recirculation and an increase in the polishing pond operating level. Both variations were within the guidelines described in the O & M manual. This system exemplifies the need for simplicity in design and the resulting ease of operation.

Maintenance requirements for the three sampling sites were basically the same, except for the increase in requirements for the Mt. Shasta facility due to its more complex nature and larger size. Each of the sampling sites used the same basic processes that require common routine maintenance to provide a normal design service life.

Table 11 presents a summary of the reported maintenance requirements for each of the three sample sites for a period of approximately one year. The Moriarty, N.M., and Ailey, Ga., portions are the most complete and representative requirements of maintenance for a lagoon and intermittent sand filter operation. The Mt. Shasta facility was seemingly plagued with problems either induced or accidentally caused by the operator. These problems many times resulted in extensive repairs and in some cases complete overhaul of portions of the system, such as the repairing of the drain line from lagoon #1 after tour #1. The aeration system also was a source of many problems observed at the facility. Constant operational changes and problems in conjunction with the extensive maintenance activities have distorted the reported maintenance requirements for the Mt. Shasta facility.

The design of the Mt. Shasta facility also could have been improved and many of the problems may not have developed. For example, a lower hydraulic loading rate and a greater initial depth of filter sand would have simplified the operation, prolonged filter run times, and extended the period of operation before the sand was replaced.

OBSERVED INTERMITTENT SAND FILTER SYSTEM RUN TIMES

A summary of the observed intermittent sand filter run times or the period of time between cleaning operations or the rejuvenation (raking) process, is presented in Table 12 for the three tours at each site.

The Mt. Shasta sand filters did not provide a good service life between cleanings as a direct result of the poor operation of the filters during the period covered by the three tours. High hydraulic loading rates (slow sand filter operation) and poor maintenance techniques such as scarifying the filter surface without cleaning the sand surface are examples of the causes

TABLE 11. SUMMARY OF REPORTED MAINTENANCE

Job Description	Mount Shasta WPCF	Moriarty WWTF	Ailey STP
Daily operation and maintenance (daily monitoring)	(1.0 hr) × 7 days × 52 wks = 365	(1.0 hr) × 7 days × 52 wks = 365	(0.5 hr) × 5 days × 52 wks = 130
Filter cleaning	54[a]	28[a]	None
Filter raking	12 raking[a] 16 mixing[a]	13	22
Filter weed control	N.A.	None	26
Miscellaneous maintenance	N.A.	11	None
Grounds maintenance	42	8	28
Total reported man-hours	489 man-hours	425 man-hours	206 man-hours
Design estimated manpower requirements	2.4 man-year[b]	1 man-year[b]	1 man-year[b]
Actual reported manpower input	2.0 man-years[c]	0.28 man-year[c]	0.14 man-year[c]

[a] Man-hours with mechanical assistance.

[b] Assuming 1500 man-hours = 1 man-year

[c] Considering extra assistance for filter cleaning and weekend monitoring

TABLE 12. SUMMARY OF OBSERVED FILTER RUN TIMES

Mount Shasta Facility	Moriarty Facility	Ailey Facility
TOUR #1 (1-22-77 to 2/20/77) Discharge Range 473-4485 m^3/d Prior to tour #1 the use of the filters was limited to operational checkouts. The filters experienced short-circuiting due to freezing and the resulting washing out of the fines provided a passageway for the water with no observed plugging.	(5-19-77 to 6-17-77) Discharge Range 110-163 m^3/d Prior to tour #1 the first set of two filters had operated for approximately two months. During tour #1 the second set of filters provided 26 days of service. At the conclusion of tour #1 the third filter set provided only 5 days of service.	(3-19-77 to 4-17-77) Discharge Range 124-488 m^3/d Prior to tour #1 the intermittent sand filters had operated for 4 to 6 months before being raked during tour #1.
TOUR #2 (7-8-77 to 8-20-77) Discharge Range 473-1885 m^3/d 20 cm - 25 cm of sand was removed in two cleanings prior to tour #2. Tour #2 started with one filter section plugged and no record of previous filter run times. The two slow sand filter run durations were 5 days each. The intermittent sand filters provided 30 days of service with no signs of plugging.	(11-14-77 to 12-13-77) Discharge Range 189 m^3/d Between tour #1 and tour #2 the use of the filters was dependent upon which filters were dry with no scheduled use or record of rakings. Prior to tour #2 the filters were cleaned by the Utah State University research team and provided service through tour #2 (>30 days)	(9-15-77 to 10-14-77) Discharge Range 45-189 m^3/d In the time between tour #1 and tour #2 the filters operated for 4 months before being raked. The filters continued to provide service through tour #3.
TOUR #3 (4-14-78 to 4-28-78) Discharge Range 1184-4349 m^3/d At the end of the filter operation season of 1977 the filters were scarified down to a depth of 25 cm with no record of cleanings or run times. One filter operated for 13 days during tour #3 before plugging. The remaining filters exhibited signs of plugging.	(2-13-78 to 3-15-78) Discharge Range 189 m^3/d The filters operated continuously between tour #2 and tour #3 and through tour #3 (>4 months) with only two rakings after the tour #2 cleaning operation. The time between rakings and the filter condition prior to raking was not available.	(1-3-78 to 2-2-78) Discharge Range 223-564 m^3/d As a result of a malfunction during tour #2 one of the filters received the dosing basin overflow. This, in addition to the heavy hydraulic loading of tour #3, resulted in that filter being raked after 5 months of use. The other filter operated 7 months before requiring raking.
COMMENTS No record of the filter usage or cleaning dates were available.	Available records of filter use are incomplete for an accurate filter run time presentation.	This system promised the most consistent run time and effluent quality with no filter sand removed.

that induced the short filter run times. The filters did, however, demonstrate the ability to provide good run times when operated as intermittent sand filters under the prescribed O & M procedures. Operation under the O & M guidelines during tour #2 resulted in 30 days continuous service with no signs that filter maintenance would be required.

In the beginning of operations at the Moriarty facility the first set of intermittent sand filters provided two months of service before plugging. The filter run time for the succeeding filters demonstrated a progressive decrease from 2 months to 26 days for the second set and 5 days for the third set. This decrease in service life for the previously unused filters was caused by the wind blown clay-type topsoil deposits on the filter surfaces and calcium carbonate precipitation.

The filters were cleaned by the Utah State University research team previous to the second sampling period. Following the cleaning operation, a new mode of operation was initiated as described previously. Under the new mode of operation, the filters provided 30 days of operation with no required maintenance. The filters continued to provide service during the time between tour #2 and tour #3, and also throughout tour #3 totaling more than 4 months of operation after being cleaned. During this 4-month period the filters were reportedly raked two times as part of a routine filter maintenance procedure. Records of filter conditions prior to raking or the time between the rakings were not available. At the conclusion of tour #3 the filters did not show signs of plugging.

The operation of the Ailey facility intermittent sand filters provided the best and most accurate filter run time performance data of the three sites studied. The filters demonstrated an ability to operate from 4 to 7 months without maintenance being required. Even at the times that the raking was observed by the visiting research team, the filters were not plugged but only had some puddling in the low spots. The diligent operational monitoring of the Ailey system by the operator in conjunction with the operational design loading rate is responsible for the longevity of the filter service life. It is important to note that the Ailey filters did not require removal of the surface sand during the one year study period.

Summary of Filter Run Times for the Three Selected Sites

With proper operation and design, the intermittent sand filters can provide 4 to 6 months of maintenance-free operation. Findings of this study agree with the conclusions presented by Tupyi et al. (1977) in that high hydraulic loading rates produce undesirable short filter runs. This sand filter operating at a hydraulic loading rate of 9360 m^3/ha·d during the Mt. Shasta tour #2 and the concurrent intermittent sand filter operation at 4680 m^3/ha·d providing more than 30 days of service treating the same volume of water.

Another important observation related to this example is the need for the filters to drain completely and be able to take in air for the biological degradation of the deposited organic material. A greater rest period between dosings enables better biodegradation of the filtered material and thus increases the filter service life.

PERFORMANCE OF SYSTEMS

General

Parameters measured at each sampling site are first discussed and illustrated graphically for each location. Discontinuous plots indicate a missing data point. All data are summarized in Appendix A in Tables A-1 through A-74.

Mt. Shasta, California

Sampling Points--

Sampling point number one was located at the facility headworks, between the comminuter and Parshall flume. Raw sewage was sampled at this point prior to entering the lagoon system. Figure 2 shows the location of the sampling stations.

The lagoon system effluent was sampled at the Parshall flume leading to the dosing basin and eventually to the intermittent sand filters. During tour #3 because lagoon #4 was out of service, the sample was obtained directly from the dosing basin. Sampling point number two was used to monitor lagoon performance or the quality of influent to the intermittent sand filters.

Filter effluent was collected as sample point number three. The effluent from the intermittent sand filters was obtained at the collection manhole for the filter underdrain system prior to disinfection. During tour #2 when intermittent and slow sand filters were operated in parallel operation, sample number three was obtained at separate filter section outlets as illustrated in Figure 6. Parallel operation of the filters produced two samples at sampling point number three and each sample was evaluated separately. Slow sand filter performance is presented in a later section.

Chlorinated filter effluent was collected at the catch basin between the disinfection system and the outfall system. This sampling station was designated number 4.

Summary of Results--

A summary of the results for the Mt. Shasta wastewater treatment plant is presented in Table 13. Results are presented by tour and sampling point, and the percentage removals obtained with each component of the system are also presented in Table 13. Each of the parameters measured is discussed by sampling point locations in the following sections.

Total Biochemical Oxygen Demand (BOD_5)--

Mean total BOD_5 concentrations for all sampling points and tours at Mt. Shasta are presented in Table 13. The daily fluctuations of the total BOD_5 are presented in Figure 8.

TABLE 13. SUMMARY OF RESULTS OBTAINED AT THE MT. SHASTA, CALIFORNIA, WASTEWATER TREATMENT SYSTEM

Parameter	Tour Number	Lagoon Influent Sampling Point #1	Lagoon Effluent Sampling Point #2		Filter Effluent Sampling Point #3		Chlorinated Filter Effluent Sampling Point #4		Overall Removal
		Concentration mg/ℓ	Concentration mg/ℓ	Removal %	Concentration mg/ℓ	Removal %	Concentration mg/ℓ	Removal %	%
Total BOD_5	1	110	26	76	21	19	14	33	87
	2	121	19	84	4	79	3	25	98
	3	110	20	82	7	65	4	43	96
Soluble BOD_5	1	36	9	75	5	44	8	-	78
	2	47	6	87	3	50	3	-	94
	3	38	5	87	4	-	3	25	92
Suspended Solids	1	85	37	56	26	30	21	19	75
	2	86	69	20	13	81	13	-	85
	3	73	33	55	11	67	11	-	85
Volatile Suspended Solids	1	74	29	61	23	21	17	26	77
	2	74	47	36	7	85	6	14	92
	3	56	21	63	5	76	4	20	93
Fecal[a] Coliform	1	0.65×10^6	720	99.89	53	92.64	<1	99.99	99.99
	2	3.38×10^6	20	99.99	2.4	88.00	1.3	45.83	99.99
	3	0.37×10^6	179	99.95	37	79.33	5	86.49	99.99
pH[b] In Situ	1	7.1 (6.7 - 7.6)	8.3 (7.4 - 9.0)	-	6.4 (6.0 - 7.0)	-	6.3 (5.7 - 7.0)	-	-
	2	6.7 (6.5 - 7.0)	9.3 (8.7 - 9.7)	-	7.0 (6.7 - 7.7)	-	6.7 (6.4 - 7.3)	-	-
	3	6.9 (6.8 - 7.0)	8.5 (7.5 - 9.3)	- -	7.1 (6.6 - 7.5)	-	6.8 (6.3 - 7.3)	-	-

continued

TABLE 13. CONTINUED

Parameter	Tour Number	Lagoon Influent Sampling Point #1	Lagoon Effluent Sampling Point #2		Filter Effluent Sampling Point #3		Chlorinated Filter Effluent Sampling Point #4		Overall Removal
		Concentration mg/ℓ	Concentration mg/ℓ	Removal %	Concentration mg/ℓ	Removal %	Concentration mg/ℓ	Removal %	%
Temper-ature^c In Situ	1	9.7	5.8	-	5.7	-	5.1	-	-
	2	21.3	24.4	-	23.8	-	24.3	-	-
	3	10.8	11.0	-	10.7	-	11.3	-	-
Dissolved Oxygen In Situ	1	5.5	14.0	-	4.5	-	3.2	-	-
	2	3.0	11.4	-	6.1	-	6.3	-	-
	3	6.9	10.9	-	6.1	-	7.5	-	-
Total COD	1	181	94	48	64	32	54	16	70
	2	268	124	54	129	-	101	22	62
	3	323	67	79	52	22	30	42	91
Soluble COD	1	61	37	39	21	43	24	-	61
	2	215	115	47	123	-	92	25	57
	3	246	54	78	40	26	23	43	91
Alkalinity	1	86	79	8	57	28	47	18	45
	2	110	73	34	42	42	37	12	66
	3	83	71	14	55	23	40	27	52
Total Phosphorus	1	4.05	3.40	16	3.01	11	2.81	66	31
	2	5.87	5.07	14	3.80	25	3.15	17	46
	3	3.63	2.53	30	1.90	25	1.70	11	53
Flow^d Rate	1	0.572	-	-	-	-	0.530	-	7
	2	0.566	-	-	-	-	0.265	-	53
	3	0.905	-		-	-	0.694	-	23

^{a}Expressed in organisms/100 mℓ. ^{b}Expressed as geometric mean in pH units (range of values).
^{c}Expressed in °C. ^{d}Expressed in million gallons/day.

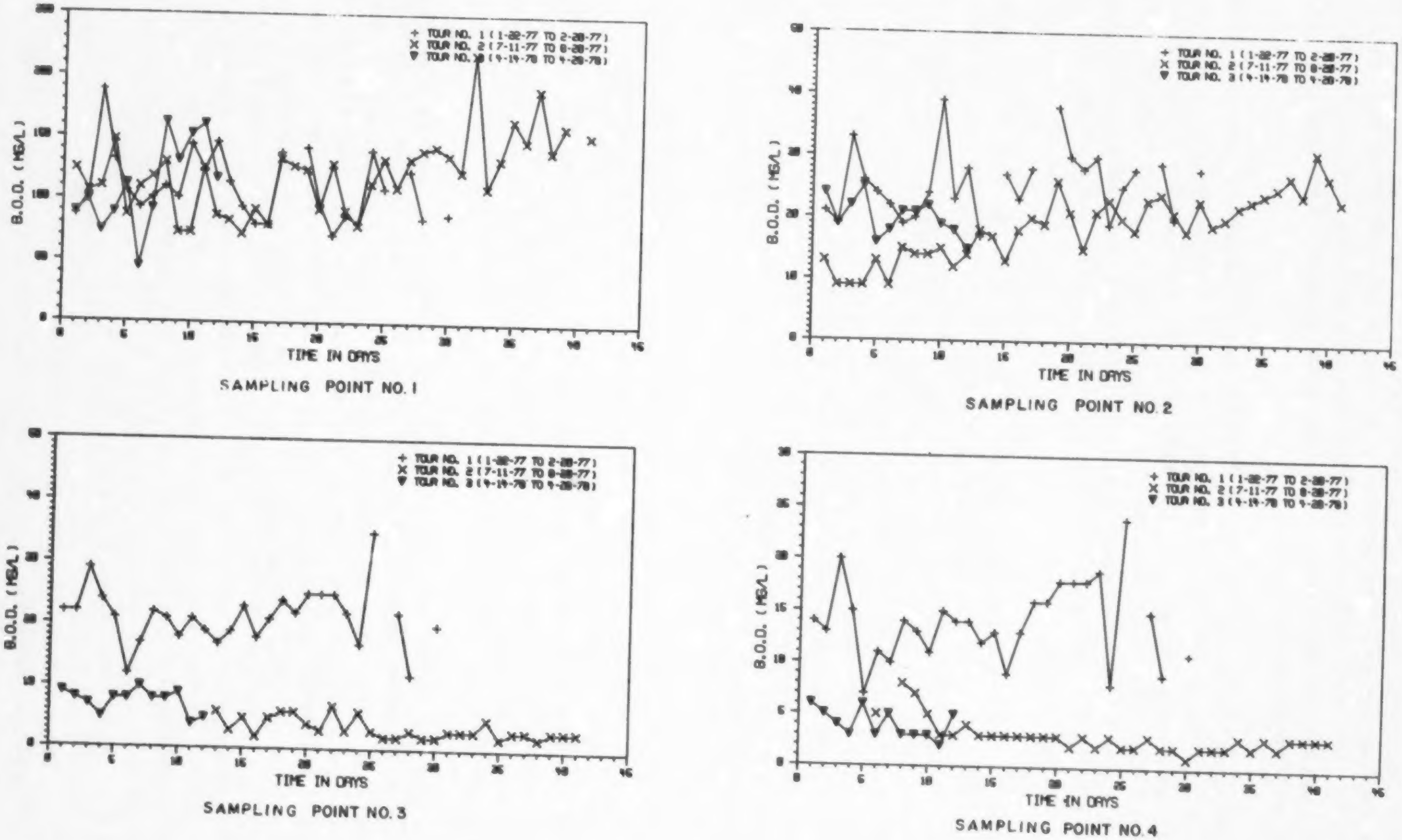

Figure 8. The relationship observed between biochemical oxygen demand (BOD_5) and time in days for the three tours at each of the four sampling points used to monitor the Mount Shasta water pollution control facility.

Sampling point #1--The variation in the influent BOD_5 concentration with time is shown in Figure 8. Mean BOD_5 concentrations of 100 mg/l, 121 mg/l, and 110 mg/l were measured during the three visits to the Mt. Shasta facility (Table 13). These low values are probably a result of infiltration into the collection system. The raw wastewater BOD_5 concentrations remained relatively constant throughout the year, and the same general fluctuations were observed during all three visits.

Sampling point #2--Even with the multiple operational variations encountered, the lagoon system produced consistently good BOD_5 removals. The most erratic fluctuations were caused by the operational variations made to facilitate the repair of the aeration system and related problems resulting during tour #3. A tour #3 mean BOD_5 concentration of 20 mg/l was obtained (Table 13). The other two tours (#1 and #2) produced mean BOD_5 concentrations of 26 and 19 mg/l, respectively.

Sampling point #3--A comparison of the BOD_5 data collected at sampling point #2 with data collected at sampling point #3 for the first tour indicates that BOD_5 removal was minimal, and on some days the BOD_5 concentration in the filter effluent was higher than that applied to the filter (Figure 8). For example, on the 25th sampling day the wastewater applied to the filter contained a BOD_5 concentration of 28 mg/l and the filter effluent contained 35 mg/l. As described previously, tour #1 was troubled with frozen filters and abnormally high loading rates. Both problems contributed to the poor performance characterized by the mean applied BOD_5 concentration of 26 mg/l and the mean filtered water BOD_5 of 21 mg/l, resulting in an overall filter removal rate for tour #1 of 19 percent.

During tours #2 and #3 the filters consistently produced high quality effluents, and the mean BOD_5 concentrations were 4 and 7 mg/l, respectively (Table 13). Individual concentrations ranged from 2 to 10 mg/l. As illustrated in Figure 8, the BOD_5 concentrations varied little from day to day. The BOD_5 removals by the filters for the last two sampling periods were 79 and 65 percent, respectively. This high filter efficiency shows the impact that correcting operational deficiencies has on effluent quality.

Sampling point #4--BOD_5 concentrations and variations in the samples collected at point #4 were essentially the same as those collected at sampling point #3 (Figure 8). The only exception was the observed decrease in BOD_5 concentration in the disinfected sample during tour #1 when the filter effluent concentrations were relatively high prior to chlorination. An additional 33 percent of the BOD_5 was removed by disinfection resulting in a mean of 14 mg/l and a range of 7 to 24 mg/l. This additional removal of BOD_5 was probably attributable to settling of solids in the chlorine contact tank. Significant differences between the BOD_5 concentrations in the filter effluent and the chlorinated filter effluent were not found during tours #2 and #3 when the suspended solids concentrations in the filter effluents were 50 percent or less of that measured during tour #1.

Total Biochemical Oxygen Demand with Nitrification Inhibitor--

Figure 9 shows the results of BOD_5 measurements with the nitrification inhibitor allyl-thiourea added (Young, 1973). Only the BOD_5 concentrations

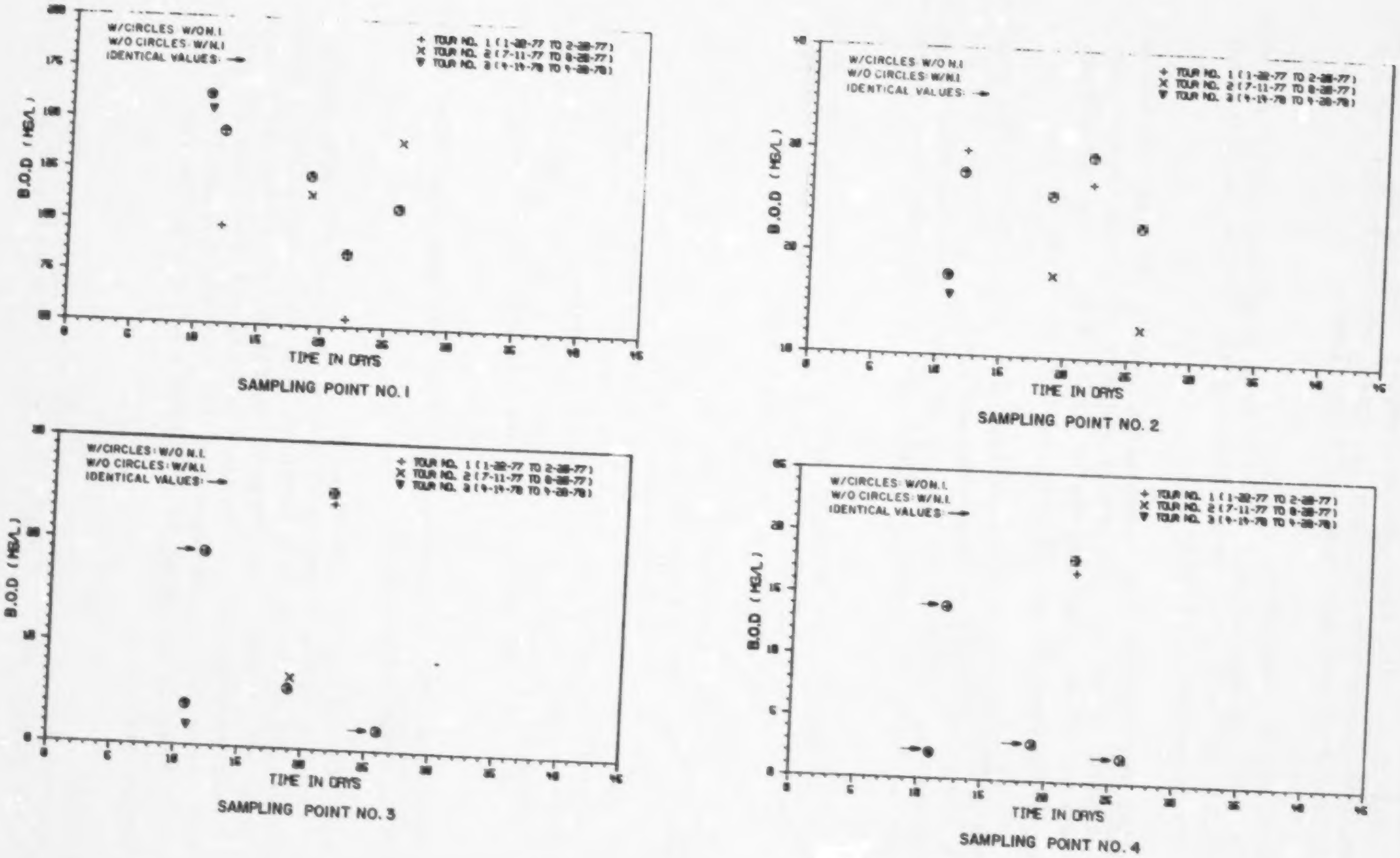

Figure 9. The relationship observed between total biochemical and biochemical oxygen demand with the nitrification inhibitor allyl-thiourea for those days during the three tours when simultaneous analyses were performed to monitor the Mount Shasta water pollution control facility.

in the raw wastewater were affected by the nitrification inhibitor and this effect was not consistent. The mean raw wastewater BOD_5 concentrations measured with and without inhibitor (112 and 126 mg/l, respectively) did not differ statistically at the 1 percent level of significance.

Soluble Biochemical Oxygen Demand--

Mean soluble BOD_5 concentrations for all four sampling points and three tours are summarized in Table 13. Daily fluctuations in the soluble BOD_5 concentrations are presented in Figure 10.

Sampling point #1--Soluble BOD_5 concentrations in the raw wastewater are shown in Figure 10. The raw wastewater soluble BOD_5 constituted approximately 35 percent of the raw wastewater total BOD_5. The percentage soluble BOD_5 ranged between 33 and 39 percent for the three tours.

Sampling point #2--The only major deviation in the soluble BOD_5 concentrations in the lagoon effluent occurred during tour #1. During this period the mean concentration of soluble BOD_5 was 9 mg/l with a range of 3-15 mg/l (Figure 10). The variance was related to the multiple operational variations mentioned earlier.

During tours #2 and #3, the soluble BOD_5 concentrations in the lagoon effluent were relatively consistent. This consistency was attributable to minimal operational changes during these two tours.

Sampling point #3--As discussed in the section on total BOD_5, occasionally during tour #1, the soluble BOD_5 in the filter effluent was greater than the soluble BOD_5 in the applied water (Figure 10). Such an event occurred on day five when the soluble filtered BOD_5 concentration in the filter effluent was 14 mg/l and the lagoon effluent contained only 10 mg/l. This condition was caused by the frozen filters during tour #1. Short circuiting and flushing of solids from the filter media were observed. Excluding the deviation in tour #1, the soluble BOD_5 varied very little during tours #2 and #3.

Sampling point #4--The variations discussed for sampling point #3 are also applicable to sampling point #4.

Soluble BOD_5 with Nitrification Inhibitor--

The addition of nitrification inhibitor to the soluble BOD_5 tests produced only a slight difference between soluble BOD_5 and soluble BOD_5 with nitrification inhibitor. The largest decrease in soluble BOD_5 when using the inhibitor was observed at concentrations greater than 30 mg/l (Figure 11), but these diffrences were not statistically significant at the 1 percent level. This is the same as observed when using the inhibitor in total BOD_5 evaluations.

Suspended Solids--

Mean suspended solids concentrations for all sampling points and tours at Mt. Shasta are presented in Table 13. Daily concentrations are presented in Figure 12.

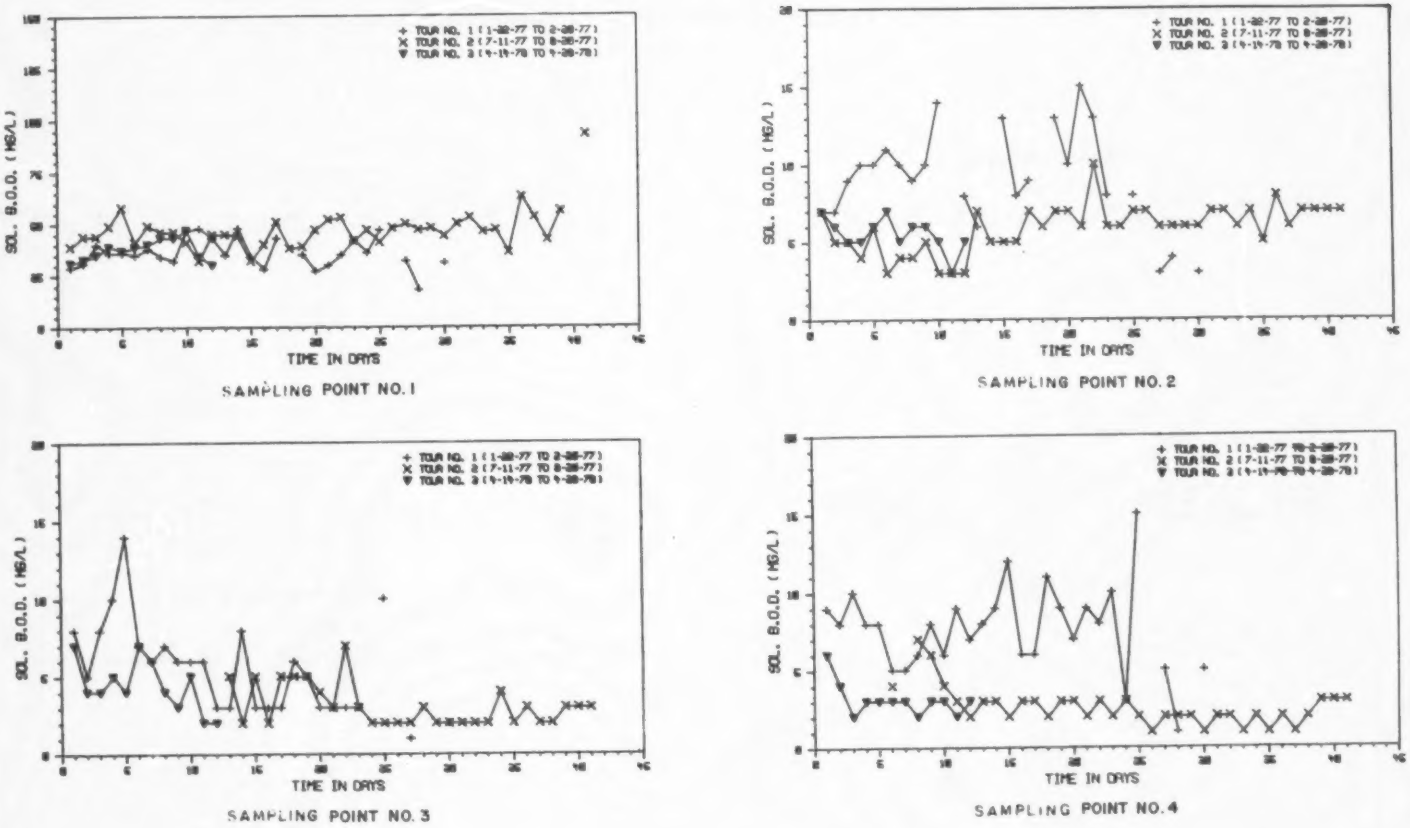

Figure 10. The relationship observed between soluble biochemical oxygen demand and time in days for the three tours at each of the four sampling points used to monitor the Mount Shasta water pollution control facility.

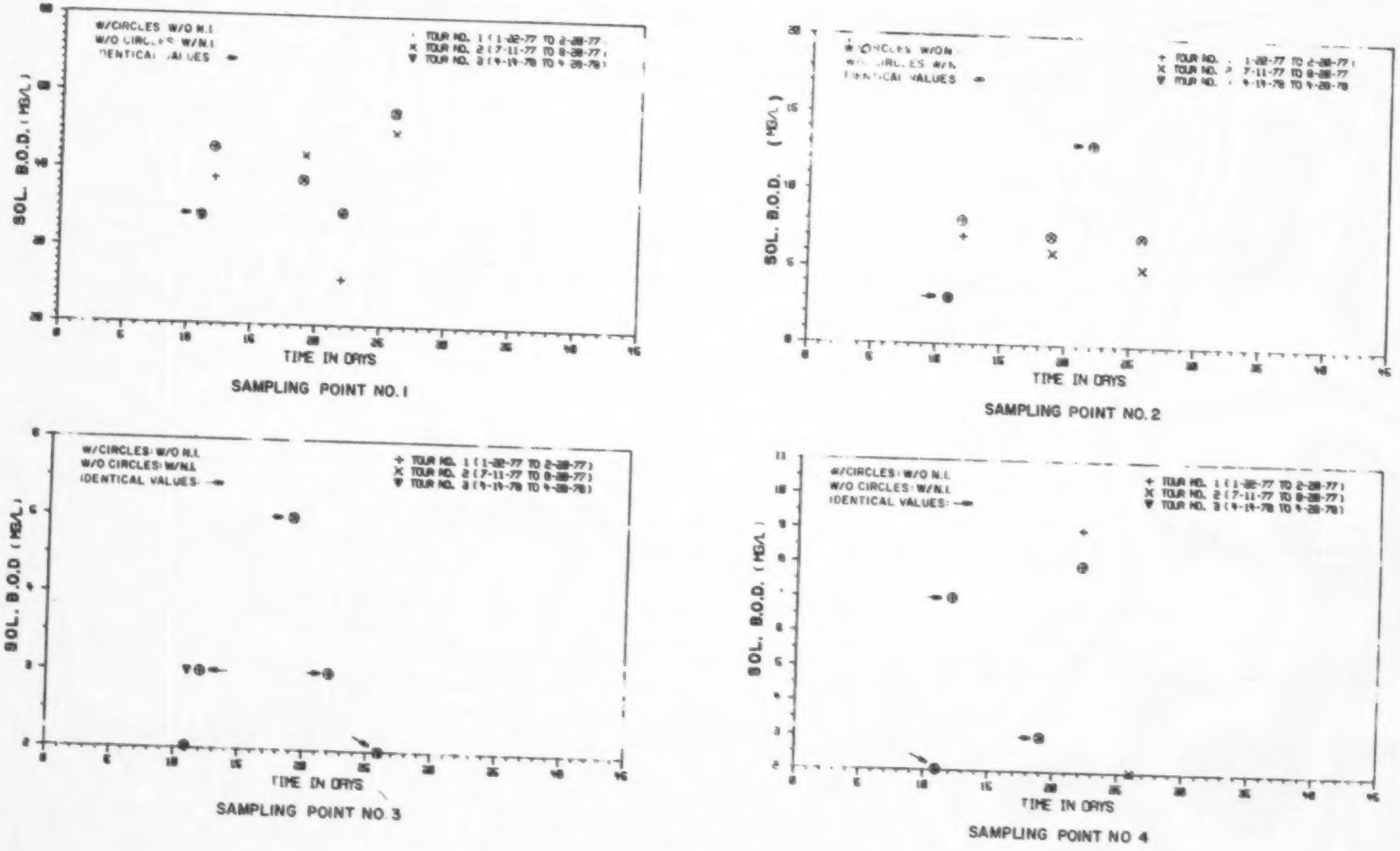

Figure 11. The relationship observed between soluble biochemical oxygen demand and soluble biochemical oxygen demand with the nitrification inhibitor allyl-thiourea for those days during the three tours when simultaneous analyses were performed to monitor the Mount Shasta water pollution control facility.

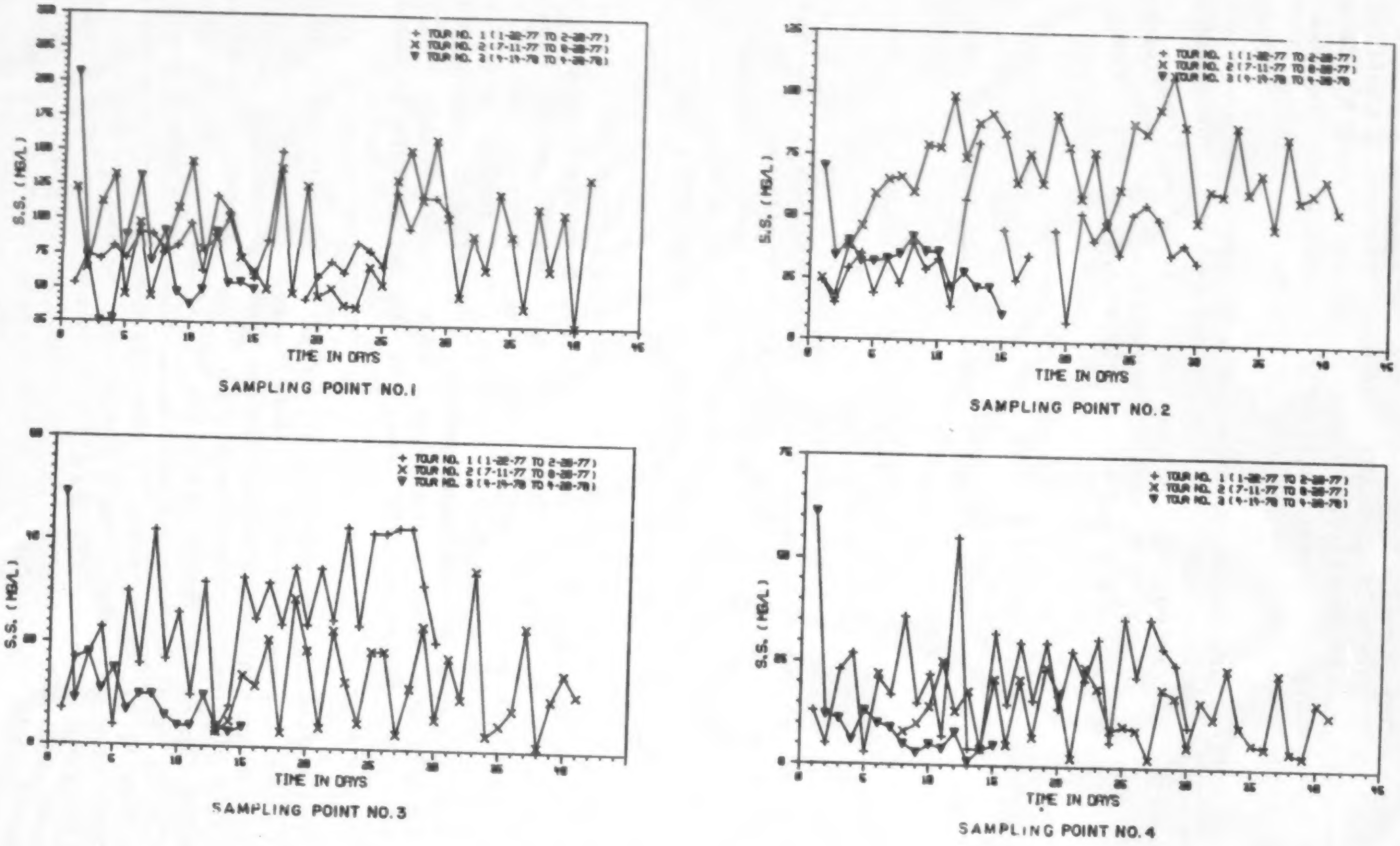

Figure 12. The relationship observed between suspended solids and time in days for the three tours at each of the four sampling points used to monitor the Mount Shasta water pollution control facility.

Sampling Point #1--Suspended solids concentrations in the raw wastewater for the three tours varied greatly from day to day and individual values ranged from 24 mg/l to 206 mg/l (Figure 12). However, the mean concentrations for each tour were relatively consistent: tour #1, 85 mg/l; tour #2, 86 mg/l; and tour #3, 73 mg/l (Table 13). These relatively low mean concentrations were probably due to infiltration into the collection system.

Sampling Point #2--Tours #1 and #3 produced more consistent and lower suspended solids concentrations than observed during tour #2. The means for the three tours were 37 mg/l (tour #1), 69 mg/l (tour #2), and 33 mg/l (tour #3). Extreme variations in suspended solids concentrations were observed during tour #1 reflecting the operating problems discussed earlier (Figure 12).

The large variations and the mean suspended solids concentrations of 69 mg/l observed during tour #2 is nearly twice the value obtained during the other tours. This increase is attributable to the higher growth rates for algae during the summer.

Sampling Point #3--During tour #1, as discussed previously, the filters were allowed to freeze, and the problems led to occasional BOD_5 concentrations in the filter effluent greater than that in the applied water. An occasional increase was also observed with the suspended solids. On the second sampling day during tour #1 the wastewater applied to the filter contained 15 mg/l of suspended solids and the effluent contained 17 mg/l (Figure 12). The mean of 26 mg/l with a range of 3 to 43 mg/l for tour #1 illustrates the extreme fluctuations in the suspended solids concentrations during this sampling period (Table 13).

Large day to day fluctuations in the suspended solids concentrations were also observed during tour #2, but the highest percentage removal of the suspended solids by the filters (~ 81 percent) was observed at Mt. Shasta. The mean filter effluent suspended solids concentrations during tour #2 was 13 mg/l (Table 13). Although the first sample collected during tour #3 contained a high concentration of suspended solids, the effluent concentrations dropped below 20 mg/l and remained low. The mean suspended solids concentration for tour #3 at Mt. Shasta was the lowest of the three sampling periods with a value of 11 mg/l.

Sampling Point #4--The fluctuations occurring at sampling point #3 were also evident in the samples collected at sampling point #4. The high effluent suspended solids concentrations observed during tour #1 were reduced as the chlorinated effluent passed through the disinfection system. The settling of dead organisms in the contact basin accounted for this reduction in suspended solids. This settling effect was not as obvious during the second two sampling periods because of the decrease in the suspended solids concentrations in the filter effluent. Increases in the suspended solids in the chlorinated effluent were observed when the disinfection system had been idle for a period of time. The increase was caused by the increased velocity of flow scouring the settled solids. An example of such a disturbance occurred on the first sampling day of tour #3 when the disinfection system had been out of service for several days, the suspended solids concentrations in the filter effluent was increased from 49 to 61 mg/l.

Volatile Suspended Solids--

The mean volatile suspended solids concentrations for all sampling points and tours at Mt. Shasta are presented in Table 13. Daily fluctuations are shown in Figure 13.

Sampling point #1--Although values fluctuated widely on a day to day basis, the mean volatile suspended solids concentrations for the raw wastewater during the first two tours were 74 mg/l. A mean value of 56 mg/l was measured during tour #3 reflecting the increased influent flow rates caused by heavy rainfall during the Spring.

Sampling point #2--The mean volatile suspended solids concentrations during tours #1 and #3 were 29 mg/l and 21 mg/l, respectively; whereas, the mean concentration during tour #2 was 47 mg/l. The increase in volatile suspended solids during tour #2 reflects the increased algal activity in the summertime (Table 13 and Figure 13).

Sampling point #3--Tour #1 exhibited the most variation in daily volatile suspended solids concentrations with a range of 2 to 42 mg/l and a mean of 23 mg/l. The applied mean volatile suspended solids concentration was 29 mg/l or only 10 percent of the volatile suspended solids were removed during the period of operation with the frozen filter. The fluctuation in the concentration of volatile suspended solids in the intermittent sand filter effluent during the second and third sampling periods were minimal, and the respective means were 7 and 5 mg/l. The best removal rate was observed during tour #2 when 85 percent of the volatile suspended solids were removed by the intermittent sand filter operation.

Sampling point #4--As shown in Figure 13, the volatile suspended solids concentrations in the chlorinated effluent followed essentially the same pattern observed for sampling point #3. The volatile suspended solids concentrations were also decreased by the settling of algal cells in the chlorine contact chamber. The volatile suspended solids concentrations in the chlorinated effluent were consistently lower than those observed in the filter effluent.

Fecal Coliform--

Geometric mean fecal coliform concentrations for all sampling points and tours at Mt. Shasta are shown in Table 13. The daily concentrations are presented in Figure 14.

Sampling point #1--Seasonal effects are distinguishable between the sampling periods. The first tour during the Winter provided a range of 65,000 to 4,300,000 organisms/100 ml and a geometric mean of 650,000 organisms/100 ml. During tour #2 in the Summer, the range was 1,200,000 to 7,300,000 organisms/100 ml and a mean of 3,380,000 organisms/100 ml. Tour #3 provided the samples containing the low concentrations that were caused by the cooler Spring temperatures and principally the dilution of the wastewater by high flow rates. Concentrations ranged from 135,000 to 900,000 organisms/100 ml with a geometric mean of 374,000 organisms/100 ml.

Sampling point #2--The fecal coliform concentrations in the lagoon effluent were less than 5,000 organisms/100 ml 94 percent of the time. The

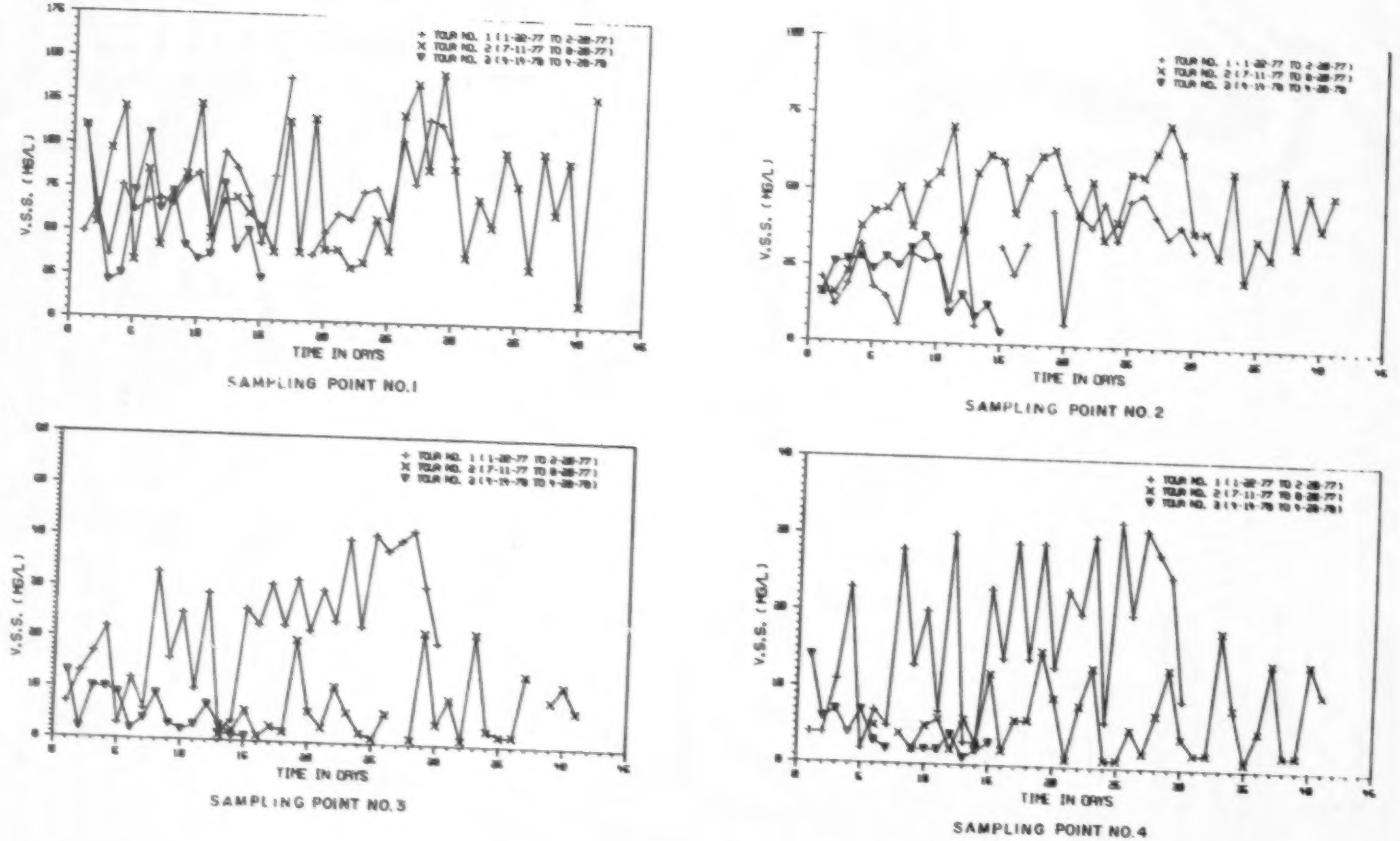

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Figure 13. The relationship observed between volatile suspended solids and time in days for the three tours at each of the four sampling points used to monitor the Mount Shasta water pollution control facility.

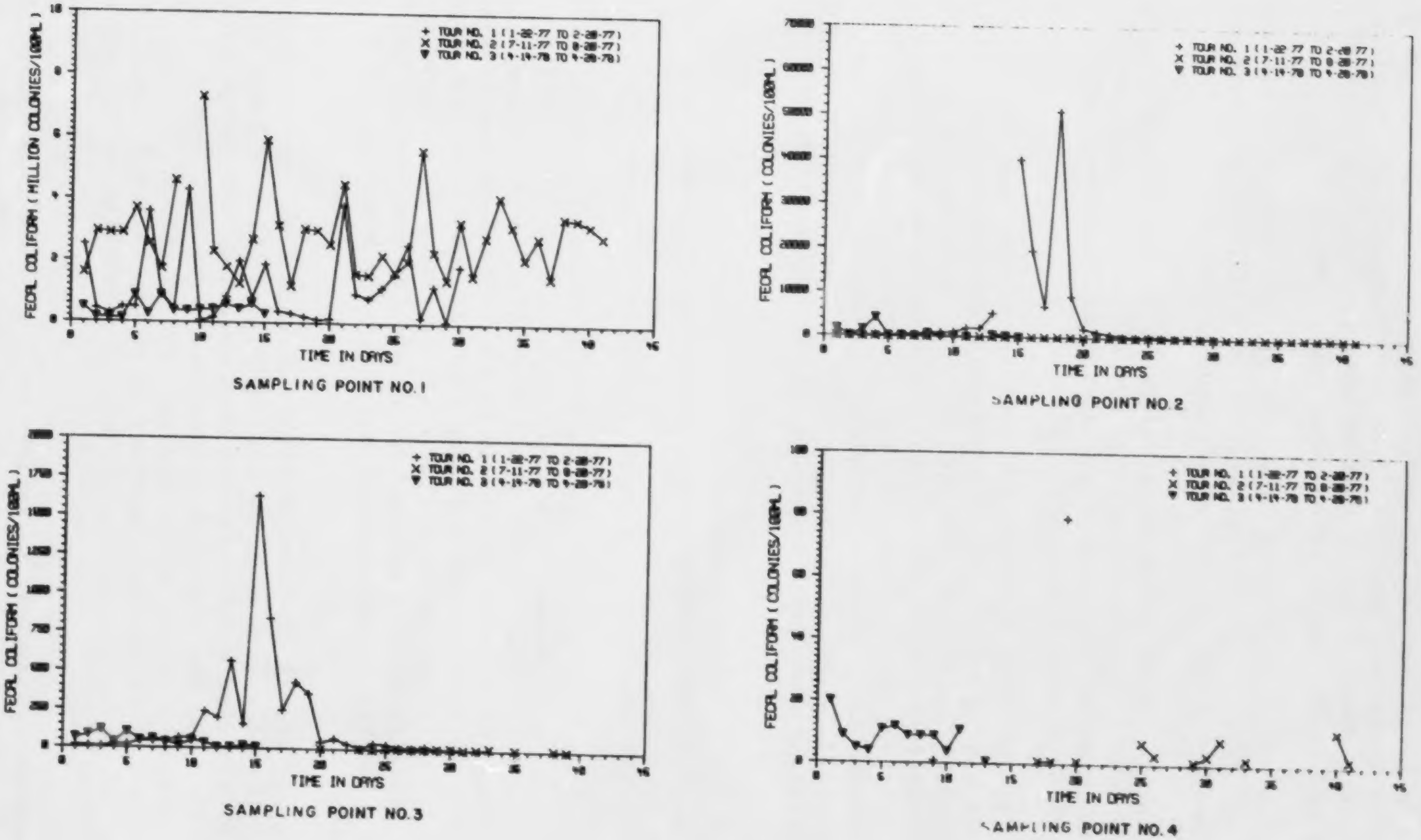

Figure 14. The relationship observed between fecal coliform bacteria and time in days for the three tours at each of the four sampling points used to monitor the Mount Shasta water pollution control facility.

large fluctuation during the middle of tour #1 at both sampling points #2 and #3 shows the effect of draining primary lagoon #1 into lagoon #4 when the bottom drain broke. A large quantity of sludge was discharged into lagoon #4. The lowest and most consistent fecal coliform concentrations for sampling points #2 and #3 were observed during tour #2 when operation of the system was almost as prescribed in the operation and maintenance manual.

Sampling point #3--Excluding the week of high concentrations observed during tour #1, the fecal coliform population in the filtered effluent was below 120 organisms/100 ml during all three sampling periods.

Sampling point #4--Chlorinated filter effluent for the three sampling periods contained less than 1 fecal coliform per 100 ml in 71 percent of the samples collected. The maximum concentration of fecal coliform observed in the chlorinated effluent was 79 organisms/100 ml.

During tour #1 the fecal coliform concentrations were less than 1 organism/100 ml in all samples except for two days when the concentrations were 1 organism/100 ml and 79 organisms/100 ml. The chlorination system had malfunctioned on these two days. Occasional fecal coliform organisms were detected during tour #2, but the samples never exceeded 11 organisms/100 ml. During tour #3 changes made in the disinfection system resulted in less effective disinfection as shown in Figure 14. The geometric mean fecal coliform concentration during tour #3 was 5 organisms/100 ml and ranged from 0 to 20 organisms/100 ml.

In Situ pH, Temperature, Dissolved Oxygen--

Mean in situ pH values, temperatures, and dissolved oxygen concentrations for all sampling locations and tours at Mt. Shasta are presented in Table 13. Daily fluctuations are presented in Figures 15, 16 and 17, respectively.

Sampling point #1--The mean temperature of the raw wastewater differed only by 1.1 C during tours #1 and #3, and the means were 9.7 and 10.8 C, respectively (Table 13). Temperatures measured during tour #2 (Summer) ranged between 20 and 26 C, and the mean value was 24.4 C. The dissolved oxygen concentrations were fairly consistent during tours #1 and #3 and the respective means were 5.5 mg/l and 6.9 mg/l (Table 13 and Figure 17). Dissolved oxygen levels fluctuated greatly during tour #2 and the mean concentration of 3.0 mg/l reflects the higher temperatures and increased bacterial activity during the Summer.

Sampling points #2, #3, #4--The pH values at each sampling location indicate different trends for each sampling period (Figure 15). At sampling point #2 during tour #1 the most erratic results were obtained, and the pH values ranged from 7.4 to 9.1. The higher pH values observed during tour #2 reflect increased algal activity in the lagoon system. The pH values for tour #3 ranged from 7.5 to 9.3. A constant decrease in pH was observed during this sampling period indicating a change in biological population in the lagoon system.

Seasonal ambient temperature variations are reflected in the water temperatures measured at sampling points #2, #3, and #4 (Figure 16). The

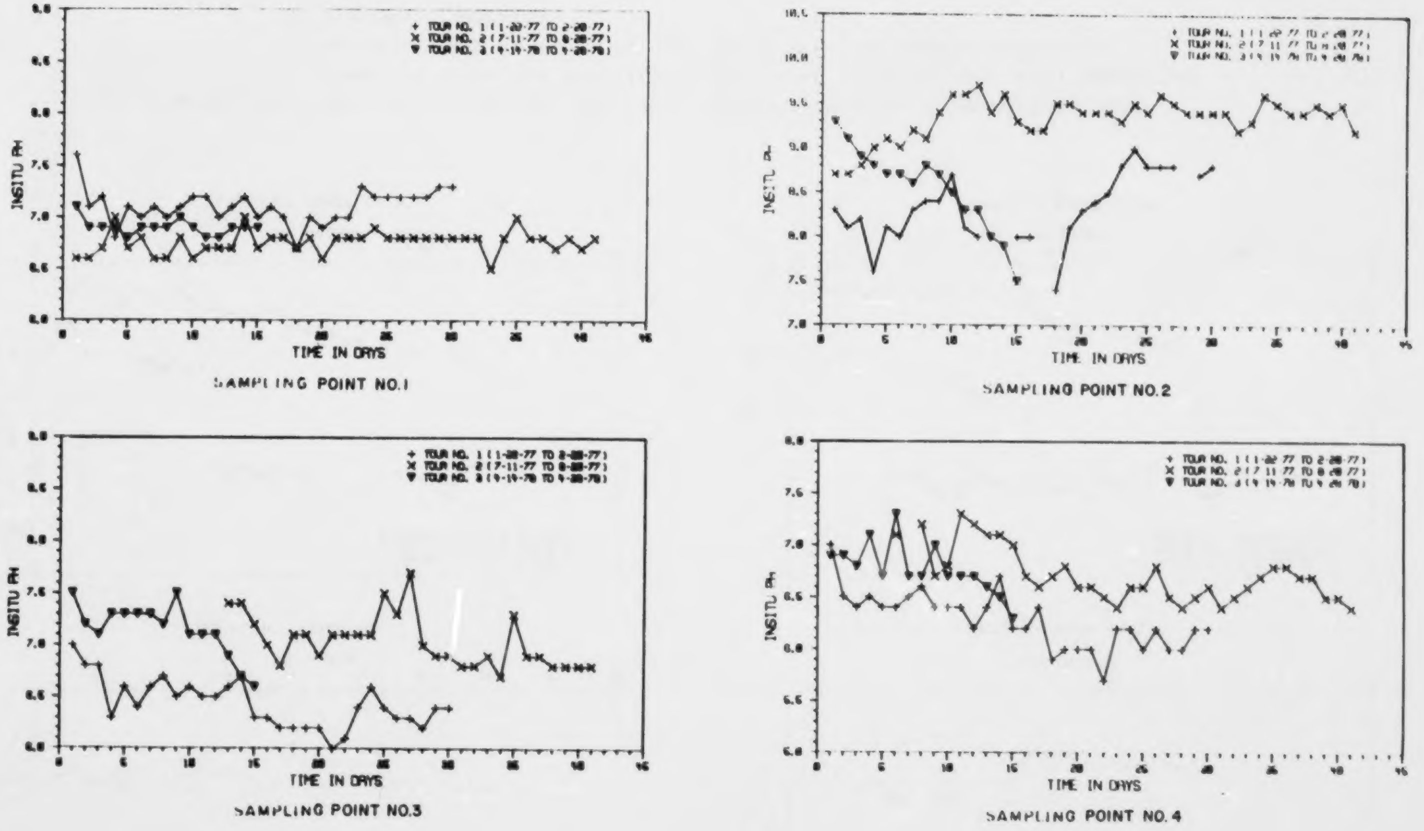

Figure 15. The relationship observed between in situ pH and time in days for the three tours at each of the four sampling points used to monitor the Mount Shasta water pollution control facility.

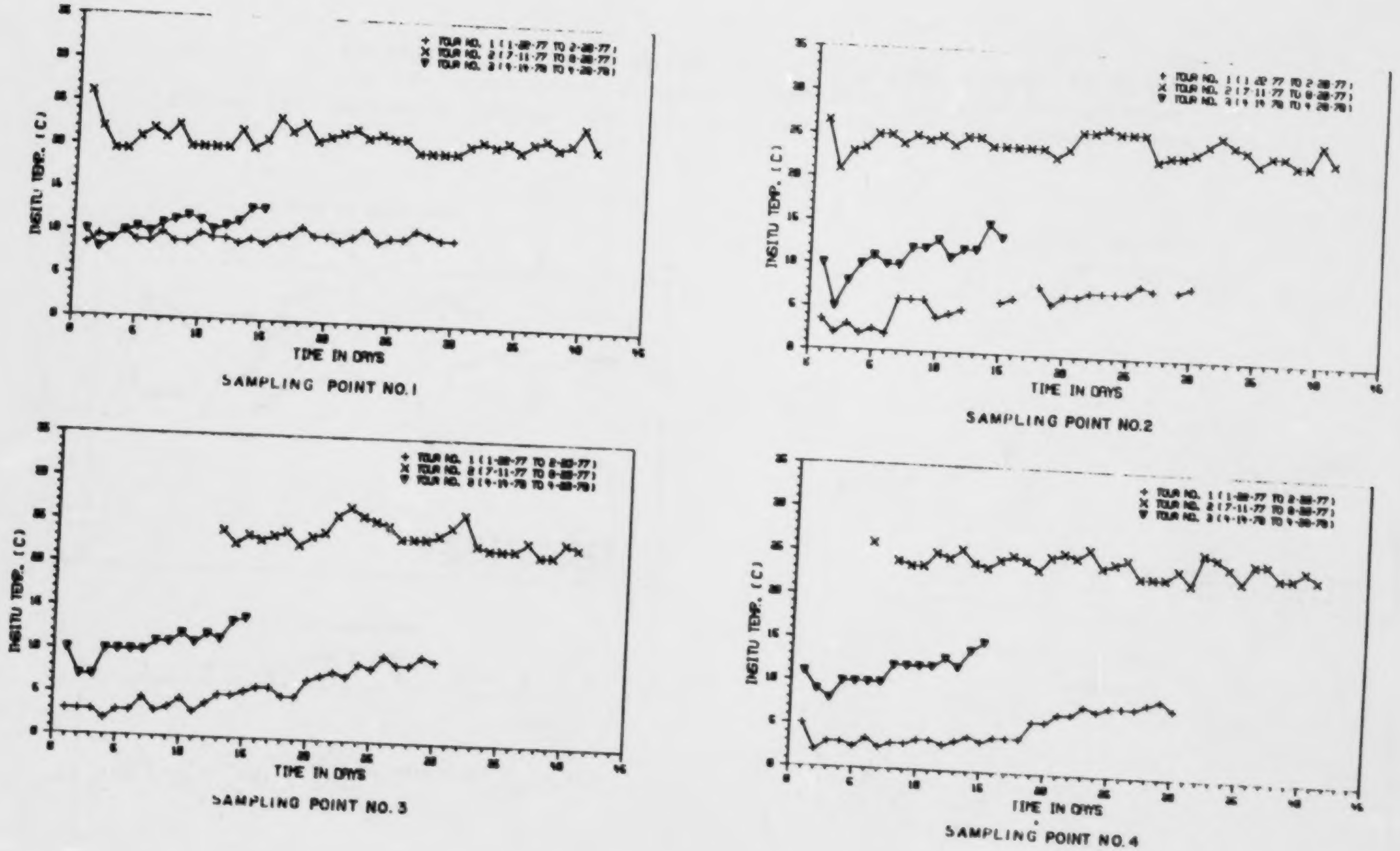

Figure 16. The relationship observed between in situ temperature and time in days for the three tours at each of the four sampling points used to monitor the Mount Shasta water pollution control facility.

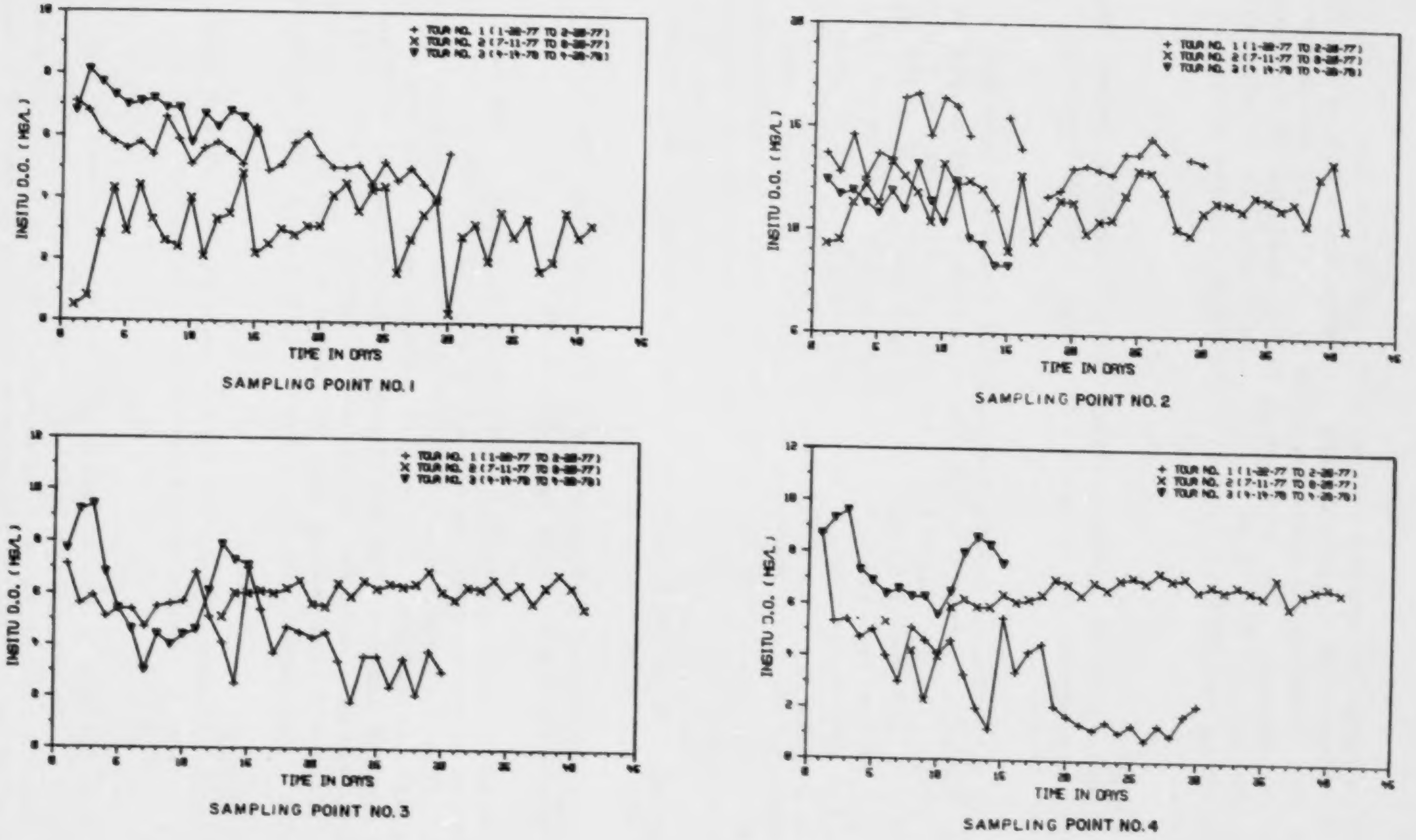

Figure 17. The relationship observed between in situ dissolved oxygen and time in days for the three tours at each of the four sampling points used to monitor the Mount Shasta water pollution control facility.

respective mean water temperatures measured during tours #1, #2, and #3 were 5.5 C, 24.2 C and 11.0 C.

The dissolved oxygen (DO) concentrations measured in the lagoon effluent (sampling point #2) fluctuated greatly during the three tours and ranged from 8 to 18 mg/l. This wide range of DO concentrations is related to the degree of algal activity in the lagoons. The lowest mean filter effluent DO concentration was measured during tour #1. This low DO concentration is attributable to the poor condition of the filters discussed previously in the operation and maintenance section.

Chemical Oxygen Demand--

Mean chemical oxygen demand concentrations for all sampling points and tours at Mt. Shasta are summarized in Table 13. Daily fluctuations are presented in Figure 18.

Sampling point #1--Chemical Oxygen Demand (COD) concentrations measured during tour #1 ranged between 78 and 275 mg/l with a sampling period mean of 181 mg/l (Figure 18 and Table 13). During tour #2 a greater fluctuation was observed with a range of 53 mg/l to 444 mg/l and a mean of 268 mg/l. COD values for tour #3 remained relatively constant within a range of 286 to 355 mg/l, and the mean value was 323 mg/l. Although BOD_5 and SS mean concentrations in the raw wastewater did not fluctuate greatly between the three sampling periods, the data presented in Figure 18 show that a progressive increase in the mean chemical oxygen demand occurred. This gradual increase in COD concentration is caused by compounds apparently not measured by the BOD test. It is likely that the increase is caused by the runoff from the streets carrying more refractory materials not attacked by the culture used in the BOD test.

Sampling point #2--Lagoon system effluent COD concentrations varied from 64 to 145 mg/l with a mean of 94 mg/l during tour #1.

During the second sampling period, a threefold increase in COD was experienced from the eleventh sampling day until the end of the 40-day sampling period. This increase occurred on the day that the parallel filter systems were put into operation. The ballast lagoons were taken out of series with the aerated lagoons, and the lagoon effluent quality decreased. A similar increase was not noted for any other parameter. The COD concentration in the lagoon effluent during tour #2 ranged from 30 to 175 mg/l with a mean of 124 mg/l. COD removal by the lagoon system during tour #2 was 54 percent.

The mean lagoon effluent COD during tour #3 was 66 mg/l with a range of 61 to 74 mg/l. Tour #3 exhibited the lowest COD effluent values of the three tours.

Sampling point #3--The filter effluent COD values for tours #1 and #3 were very similar with respective means of 64 and 52 mg/l; however, during tour #1 the COD concentration flucturated more than during tour #3. The COD concentration in the filter effluent during tour #1 reached a maximum of 101 mg/l and during tour #3 reached a maximum of 63 mg/l. During tours

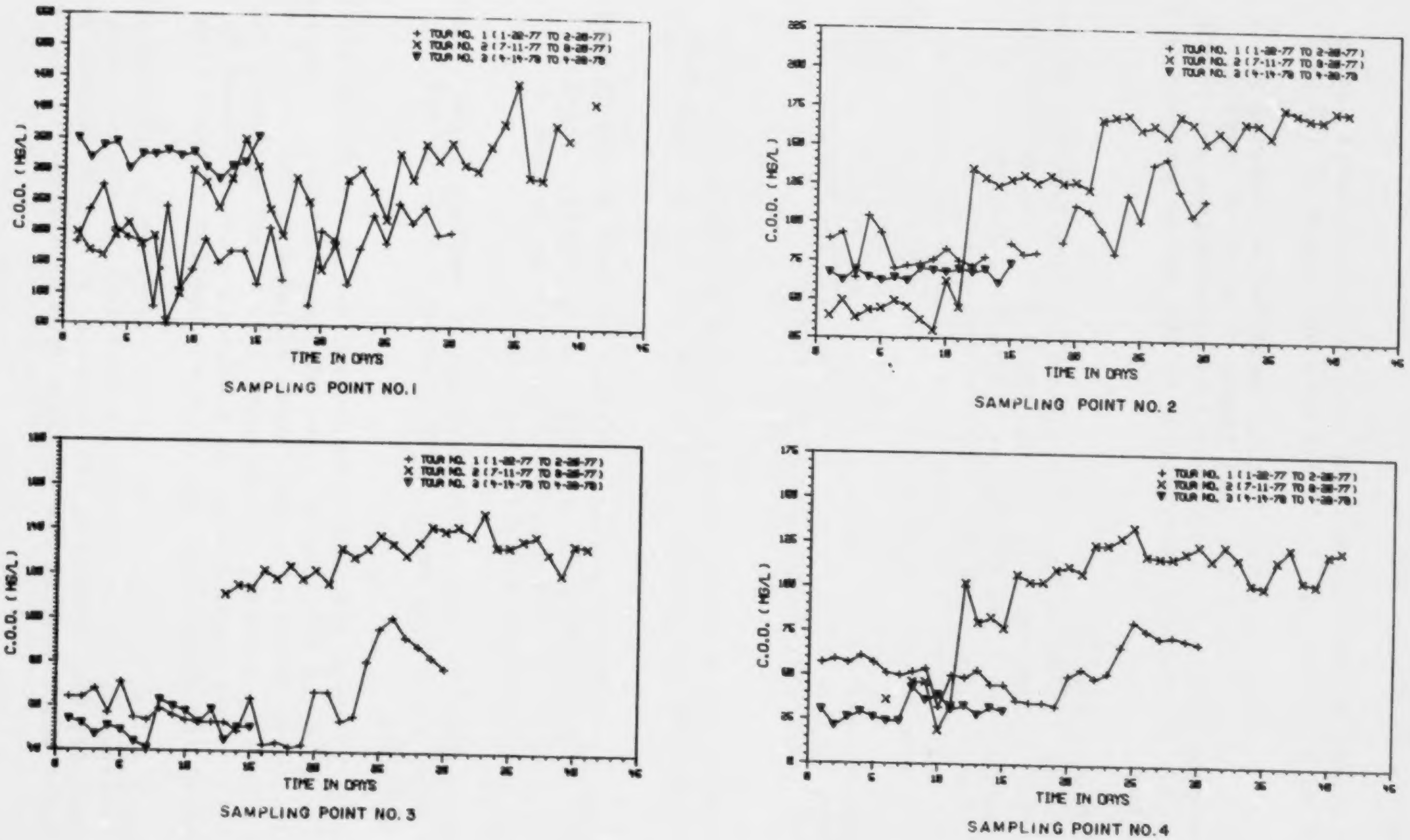

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Figure 18. The relationship observed between chemical oxygen demand and time in days for the three tours at each of the four sampling points used to monitor the Mount Shasta water pollution control facility.

#1 and #3, the minimum concentration was 41 mg/l. COD removal by the intermittent sand filter system during tours #1 and #3 were 32 percent and 22 percent, repsectively (Figure 18).

COD concentrations in the intermittent sand filter effluents during tour #2 were high with a range of 111 to 148 mg/l and a mean of 129 mg/l.

Sampling point #4--The COD concentrations measured at sampling point #4 during the three tours reflect the same trends observed at sampling point #3. The average reduction in COD caused by chlorination was 25 percent. This reduction is probably attributable to the solids settling in the chlorine contact tank.

Soluble Chemical Oxygen Demand--

General--As shown in Figure 19, the soluble COD concentrations varied essentially the same as that observed for the total COD. The general trends that were discussed for the total COD are very similar. The percent of the total COD that was soluble remained constant during each tour at the different sampling points. But considerable variation in the percentage of soluble COD was observed for the three tours. The percent of total COD represented by soluble COD during tour #1, tour #2, and tour #3 was 37, 90, and 78 percent, respectively. These differences are probably related to seasonal variations in the efficiency of the system and the seasonal increases in the COD concentration in the raw wastewater.

Alkalinity--

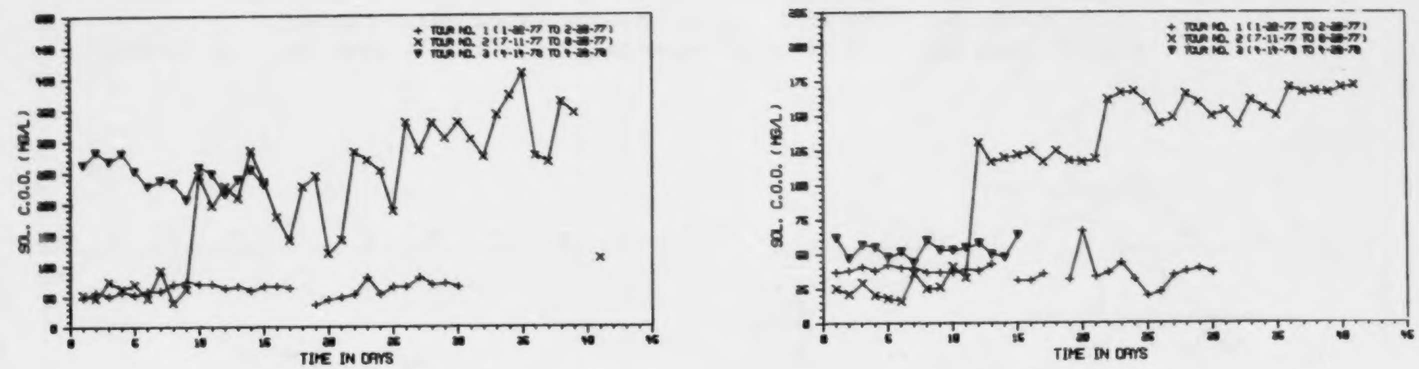
Mean alkalinity concentrations for all sampling points and tours at Mt. Shasta are summarized in Table 13. Daily fluctuations are presented in Figure 20.

Sampling point #1--Alkalinity concentrations for tour #1 and #3 were similar with means of 86 and 83 mg/l as $CaCO_3$, respectively. The mean concentration for tour #2 was 110 mg/l as $CaCO_3$ which was induced by warm temperatures and increased bacterial activity.

Sampling point #2--Alkalinity concentrations at sampling point #2 were similar for all three tours with means of 79 (tour #1), 73 (tour #2), and 71 (tour #3) mg/l as $CaCO_3$.

Sampling point #3--Mean alkalinity concentrations in the filter effluent were 57 (tour #1), 42 (tour #2), and 55 (tour #3) mg/l as $CaCO_3$. Significant reductions in alkalinity resulted as the lagoon effluent passed through the filter with the highest percentage (42 percent) loss occurring during the summer (tour #2). This higher loss during the summer is probably caused by the additional growth of the algae after the water was applied to the filter.

Sampling point #4--An additional 18 percent reduction in alkalinity was observed as the wastewater passed through the disinfection system. This reduction in alkalinity was related to the injection of sulfur dioxide as a dechlorinating agent which lowered the pH value from approximately 7.2 to 6.5.



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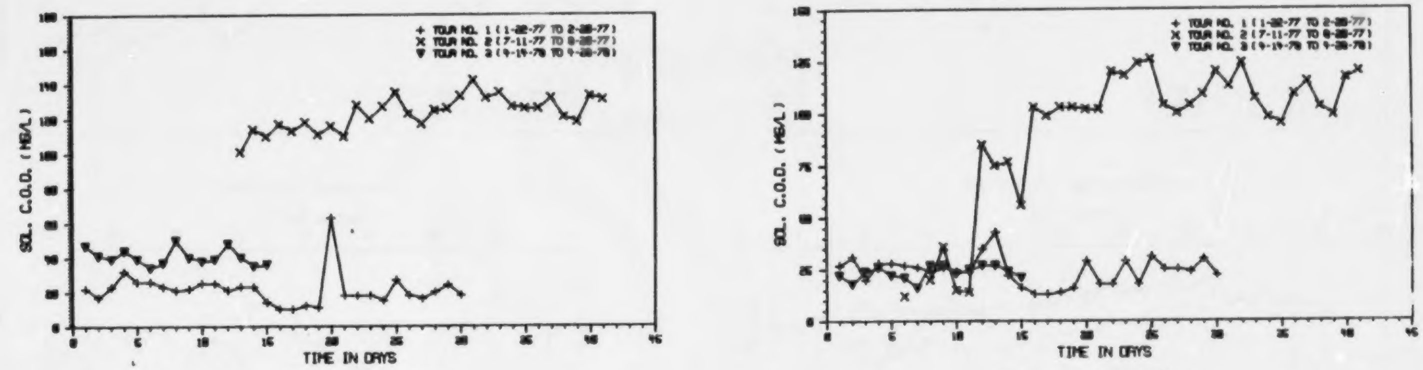

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Figure 19. The relationship observed between soluble chemical oxygen demand and time in days for the three tours at each of the four sampling points used to monitor the Mount Shasta water pollution control facility.

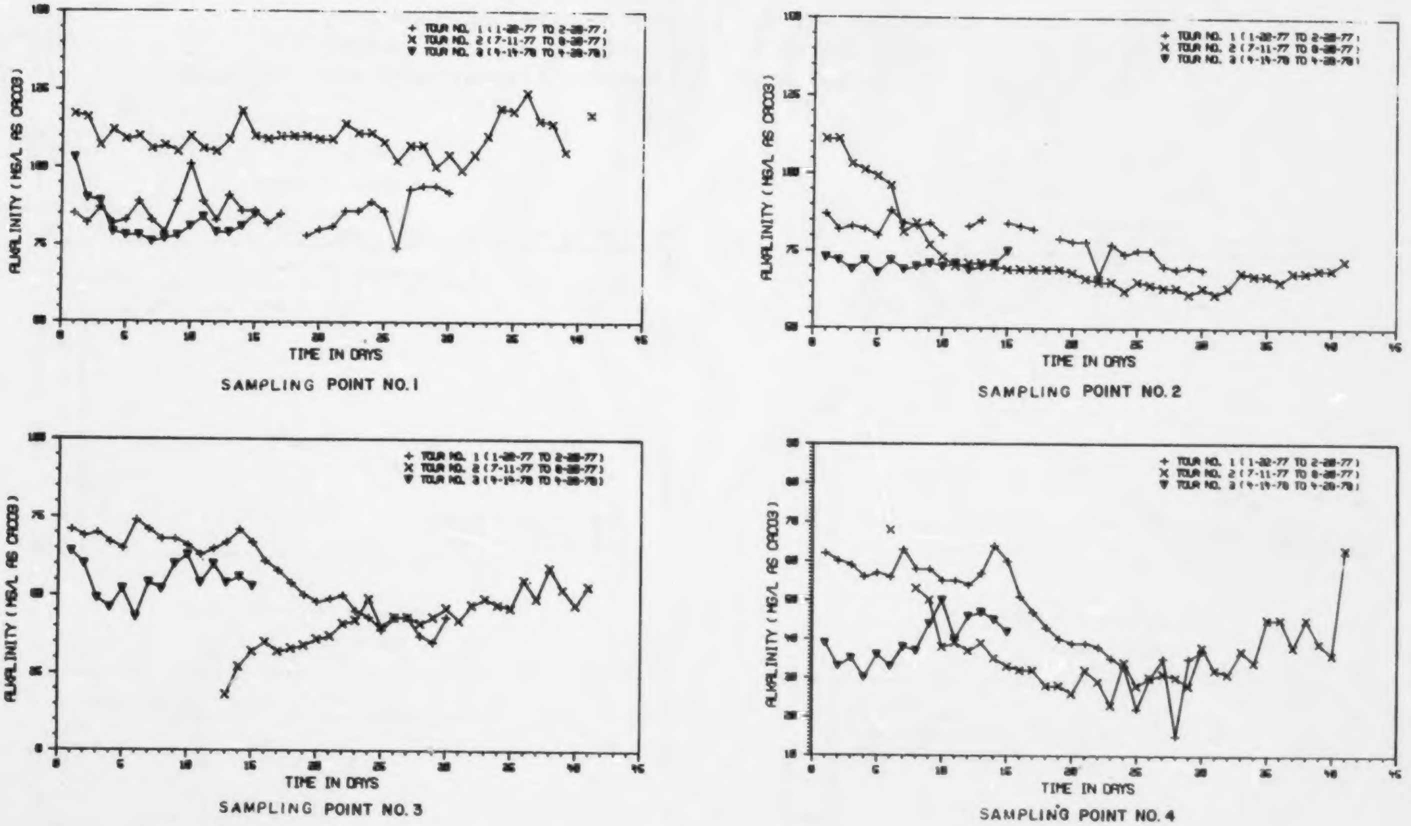


Figure 20. The relationship observed between alkalinity and time in days for the three tours at each of the four sampling points used to monitor the Mount Shasta water pollution control facility.

Total Phosphorus--

Mean total phosphorus concentrations for all sampling points and tours at Mt. Shasta are summarized in Table 13. Daily variations in the total phosphorus concentrations are shown in Figure 21.

Phosphorus removal measured at the four sampling points was consistent except during tour #2 when seasonal changes in influent concentrations and algal activity affected the phosphorus concentration (Figure 21). Total phosphorus removal through the entire facility varied with the season of the year, and removals were 31, 46, and 53 percent for tours #1, #2, and #3, respectively. Phosphorus removal in the lagoon system was not affected by the season of the year as expected. The highest percentage reduction in total phosphorus in the lagoons occurred when the water temperature was approximately 11 C. It is possible that an algae bloom occurred during tour #3 (April) and consumed or precipitated much of the phosphorus; however, the suspended solids concentrations were the lowest during tour #3.

Nitrogen Forms--

General--Five nitrogen forms were monitored and the mean concentrations over the three tours for the Mt. Shasta system are shown in Table 14. The variations with time for the five parameters plus a plot of inorganic nitrogen (NO_2-N + NO_3-N) for the three tours are shown in Figures 22-27. A discussion of the major variations is presented by nitrogen form in the following paragraphs.

Total Kjeldahl nitrogen--The total Kjeldahl nitrogen (TKN) concentrations in the raw wastewater were basically the same during all three tours (Figure 22). Mean concentrations for the three tours ranged from 14.4 to 16.3 mg N/l as shown in Table 14. The 83 percent removal in the overall system during tour #3 was attributable to high chlorine dosages being applied.

Filter effluent TKN concentrations remained essentially constant except for the last 12 days of tour #1 when a steady decline in the effluent concentrations developed. The lagoon effluent being applied to the filters also experienced a decline in TKN concentration but fluctuated more than the concentration in the filter effluent. The reduction in organic loading to the filters and the increase in filter effluent temperature of approximately 5°C probably accounted for the improved quality of the effluent (Marshall and Middlebrooks, 1974).

Ammonia nitrogen--Ammonia nitrogen conversion was much higher during tours #2 and #3 than during tour #1 when temperatures were much lower (Figures 16 and 23). During tours #2 and #3 the filter effluent ammonia nitrogen concentrations did not exceed 1 mg N/l. After the first 15 days of operation during tour #1, the filter effluent ammonia nitrogen concentrations began to decline rapidly and remained below 1 mg N/l for the last five days of sampling. This rapid declinge in ammonia nitrogen concentration and the decline in TKN discussed above are possibly explained by an increase in water temperature from 4 to 10 C (EPA, 1975).

Organic nitrogen--During the warmer weather (tours #2) the organic nitrogen concentration in the lagoon effluent increased above that detected

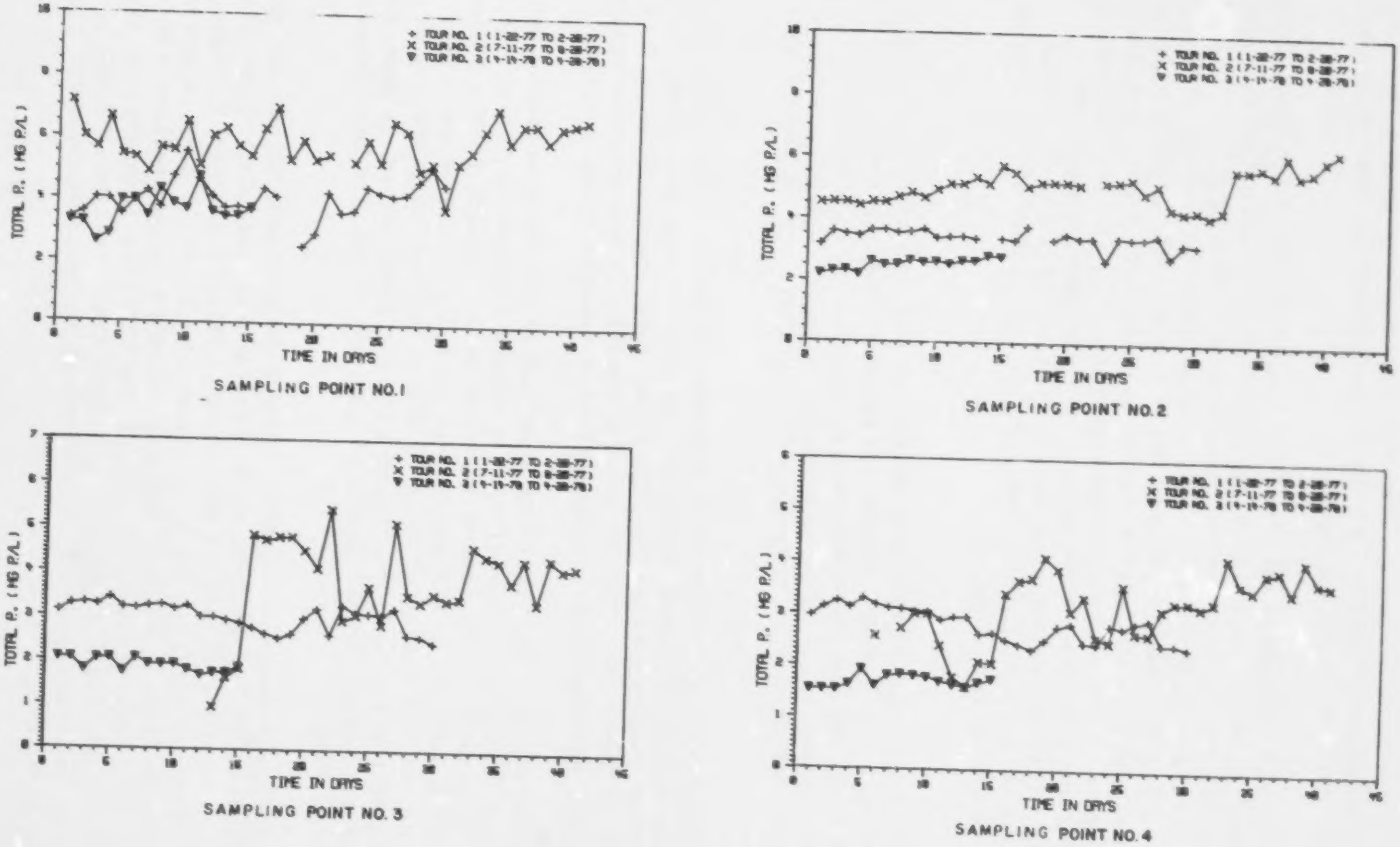
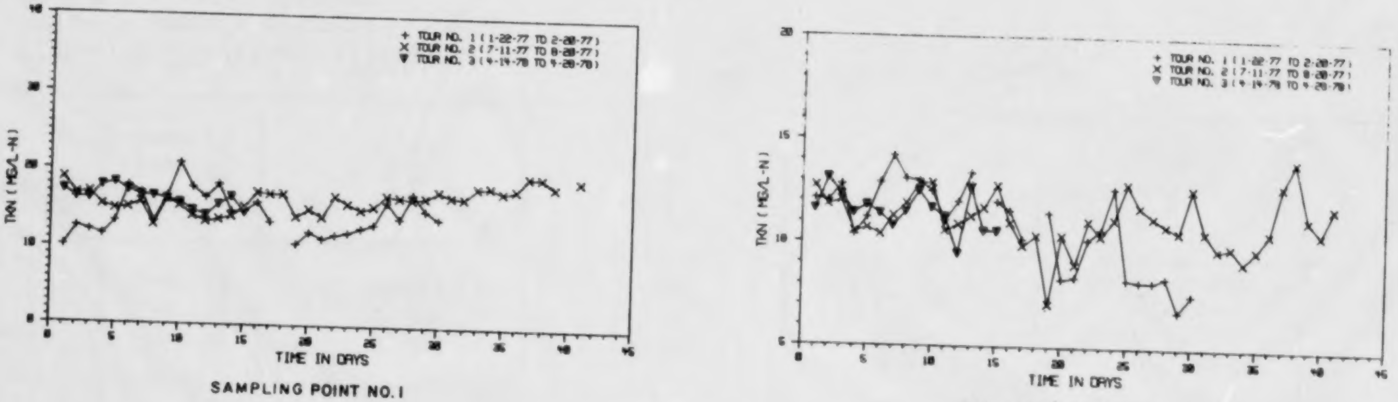


Figure 21. The relationship observed between total phosphorus and time in days for the three tours at each of the four sampling points used to monitor the Mount Shasta water pollution control facility.

TABLE 14. SUMMARY OF MEAN CONCENTRATIONS OF NITROGEN FORMS AT MT. SHASTA, CALIFORNIA

Nitrogen Form	Tour #	Lagoon Influent Concentration mg/1	Lagoon Effluent Concentration mg/1	Filter Effluent Concentration mg/1	Chlorinated Filter Effluent Concentration mg/1	Overall Removal %
TKN[a]	Tour #1	14.4	10.8	5.7	5.8	60
	Tour #2	16.3	11.1	8.6	5.7	65
	Tour #3	16.3	11.5	8.5	2.8	83
NH_3-N[b]	Tour #1	10.59	7.55	3.95	3.91	63
	Tour #2	13.0	4.09	0.41	0.26	98
	Tour #3	7.2	4.4	0.38	0.36	95
Org-N[c]	Tour #1	3.9	3.3	2.0	1.9	51
	Tour #2	3.4	7.1	8.2	5.4	-59
	Tour #3	9.1	7.1	8.1	2.4	74
NO_2-N[d]	Tour #1	0.069	0.041	0.035	0.013	-
	Tour #2	0.301	1.35	0.07	0.03	-
	Tour #3	0.081	0.083	0.125	0.014	-
NO_3-N[e]	Tour #1	0.21	0.56	5.0	5.0	-
	Tour #2	0.29	1.20	4.0	4.5	-
	Tour #3	0.40	0.43	3.51	3.45	-

[a] TKN = total Kjeldahl nitrogen
[b] NH_3-N = ammonia nitrogen
[c] Org-N = organic nitrogen
[d] NO_2-N = nitrite nitrogen
[e] NO_3-N = nitrate nitrogen



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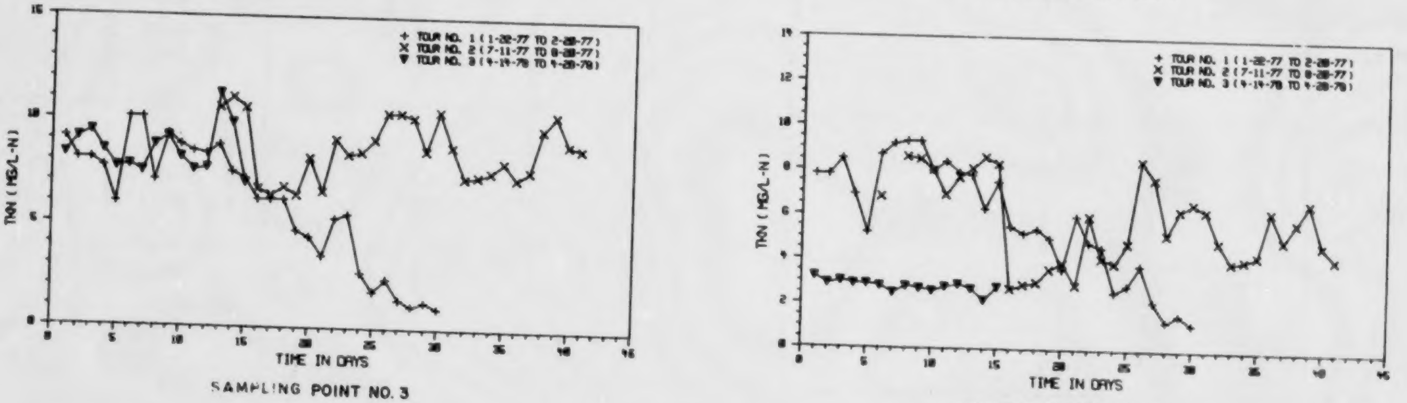

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Figure 22. The relationship observed between total kjeldahl nitrogen and time in days for the three tours at each of the four sampling points used to monitor the Mount Shasta water pollution control facility.

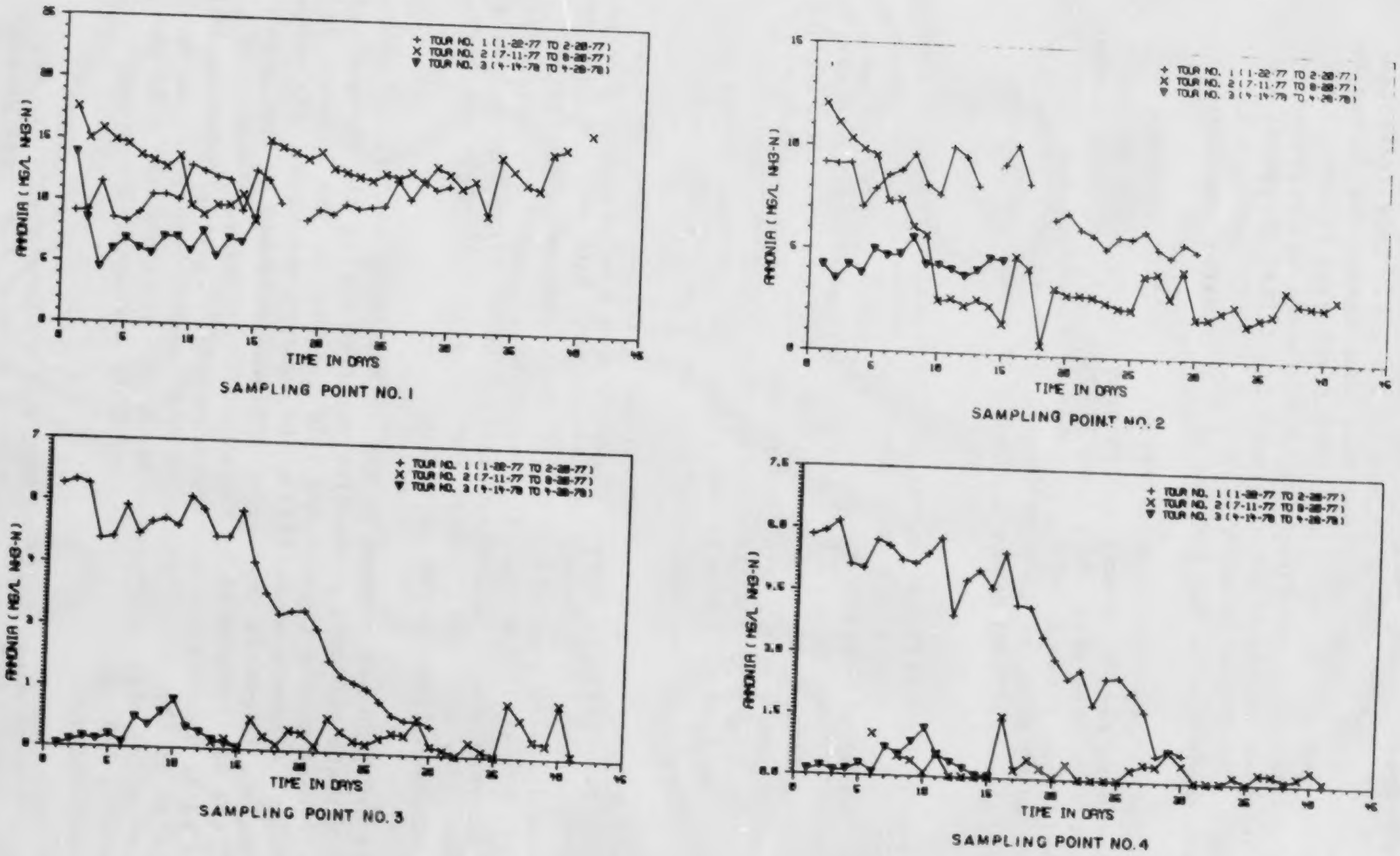

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Figure 23. The relationship observed between ammonia and time in days for the three tours at each of the four sampling points used to monitor the Mount Shasta water pollution control facility.

in the raw wastewater (Figure 24). Organic nitrogen concentrations in the filter effluent were approximately equal to the concentrations in the lagoon effluent applied to the filters (Table 13 and Figure 24). This indicates that the filter effluent contains organisms that have passed the filter or were scoured from the media. Because the intermittent sand filter is a fixed film biological reactor, the sloughing of organisms was expected, and it is known that some organisms pass through the filter (Marshall and Middlebrooks, 1974). The higher concentrations of organic nitrogen in the effluents again conform with the periods of higher water temperatures.

Nitrite nitrogen--Significant concentrations of nitrite nitrogen (NO_2-N) were observed in the Mt. Shasta system only during tours #2 and #3 when the temperatures were relatively warm (Figure 25). Nitrite nitrogen is a transitory oxidation product and is unstable. Therefore, the only significance that can be attached to high concentration of nitrite is that a significant rate of nitrification was occurring or experimental error occurred.

Nitrate nitrogen--A significant amount of nitrification occurred throughout the entire Mt. Shasta system as shown in Figure 26 and Table 14. Nitrate nitrogen (NO_3-N) production was greater in the intermittent sand filter than in the other components of the system during all three tours. The intermittent sand filter has been shown to be an effective nitrification system in many evaluations. Even when loading the filters at hydraulic loading rates greater than 9,353 m^3/ha·d during tour #3 at Mt. Shasta, nitrification was significant (Table 13 and Figure 26). A plot of the inorganic nitrogen (NO_2-N + NO_3-N) concentrations are shown in Figure 27.

Nitrogen mass balance--A mass balance of the nitrogen forms shown in Table 15 indicates that nitrogen losses in the lagoon system were higher at the cooler water temperatures during tours #1 and #3. However, nitrogen removal by the overall system was higher during the warmer sampling periods (tours #2 and #3), but still the highest removal by the total system occurred at a mild water temperature of approximately 11 C (tour #3). During tour #2 when water temperatures were the greatest and the growth of algae was high, it is likely that nitrogen fixation was occurring.

Very little nitrogen was removed by the intermittent sand filter system, but significant nitrate nitrogen production occurred during all three tours as the lagoon effluent passed through the filter. Most of the increase in nitrate nitrogen was a result of oxidizing the ammonia nitrogen. The proportion of the ammonia nitrogen in the lagoon effluent oxidized by the intermittent sand filter was influenced by the water temperature or season of the year. When the water temperature was approximately 10 C or greater, ammonia nitrogen reductions in the filter exceeded 90 percent. During the coldest tour (tour #1) when the mean water temperature was approximately 6 C, ammonia nitrogen removals by the intermittent sand filter averaged 48 percent.

Algal Concentrations--

The total number of algae cells/ml measured at sampling points #2, #3, and #4 are presented in Figure 28. A tabulation of the algal genera identified at each sampling point is presented in Table 16. The predominant algal genera varied with the season of the year.

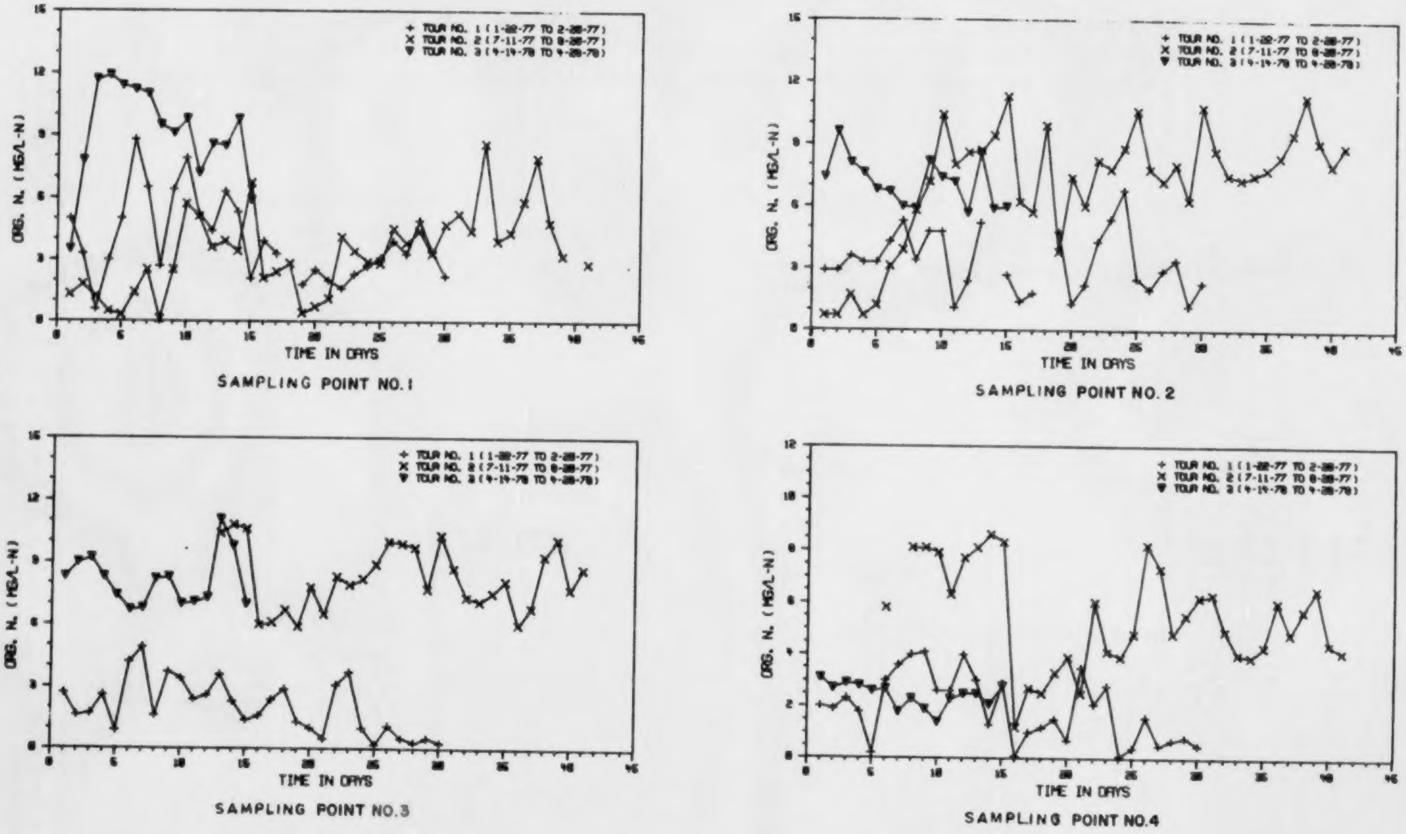

Figure 24. The relationship observed between organic nitrogen and time in days for the three tours at each of the four sampling points used to monitor the Mount Shasta water pollution control facility.

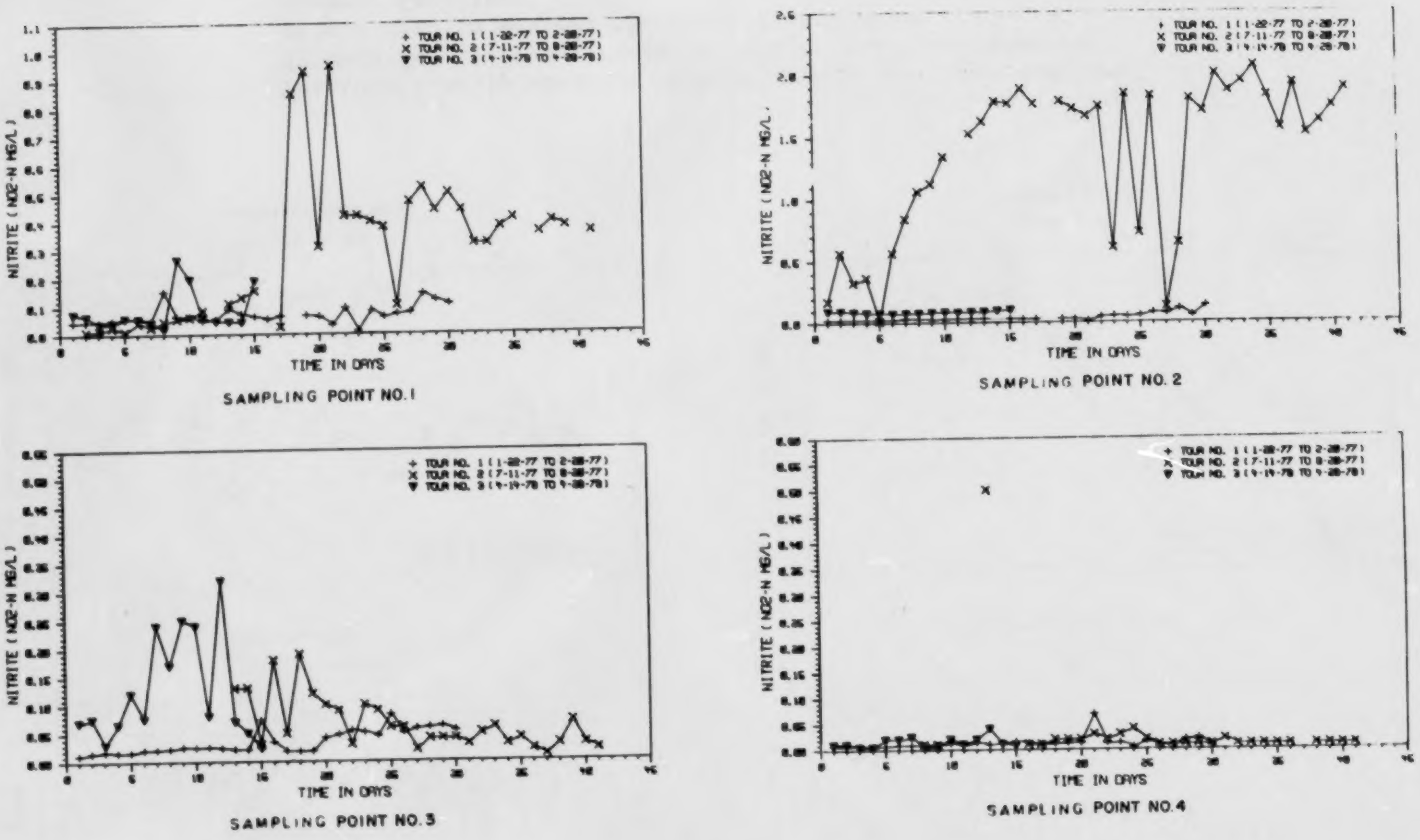

Figure 25. The relationship observed between nitrite and time in days for the three tours at each of the four sampling points used to monitor the Mount Shasta water pollution control facility.

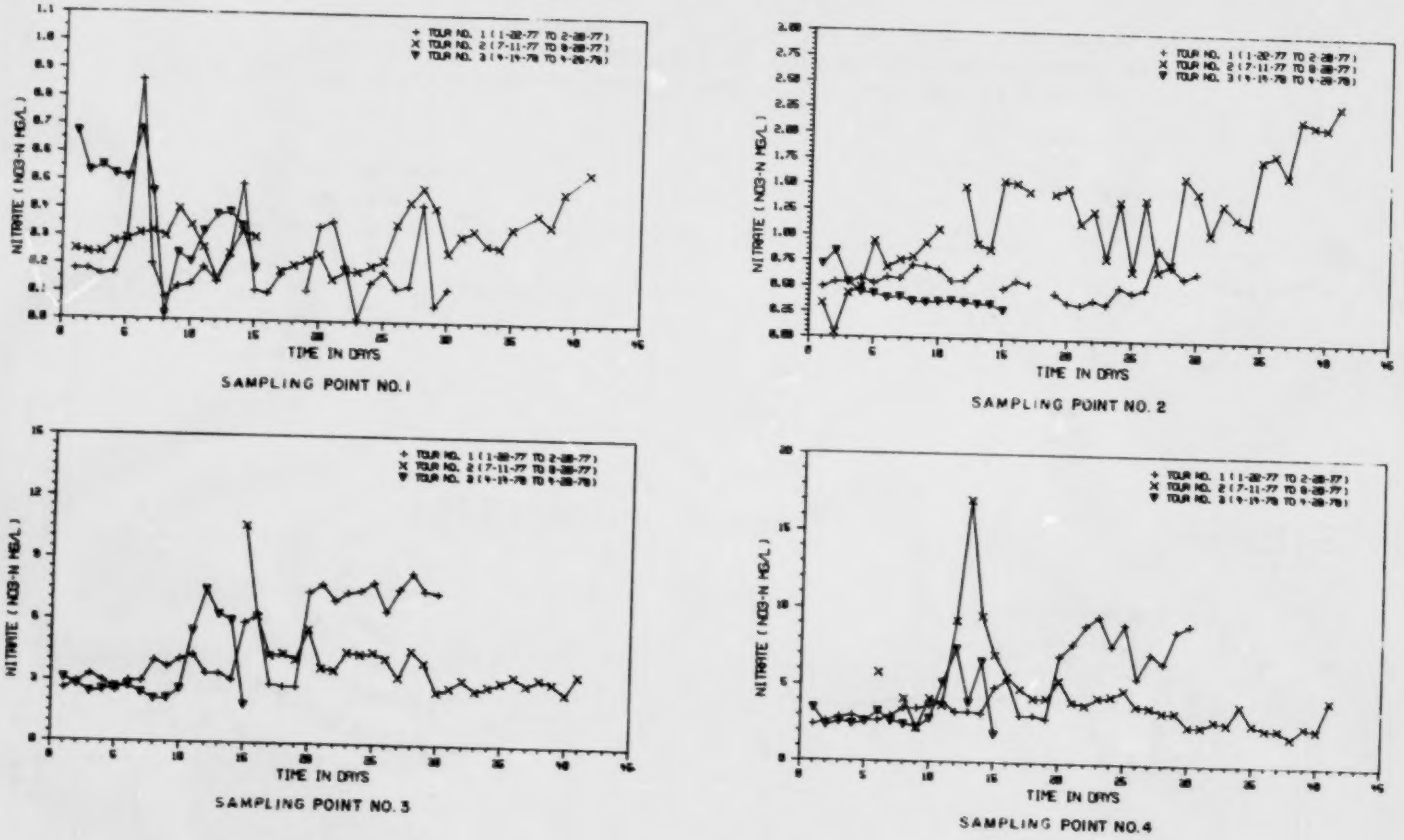

Figure 26. The relationship observed between nitrate and time in days for the three tours at each of the four sampling points used to monitor the Mount Shasta water pollution control facility.

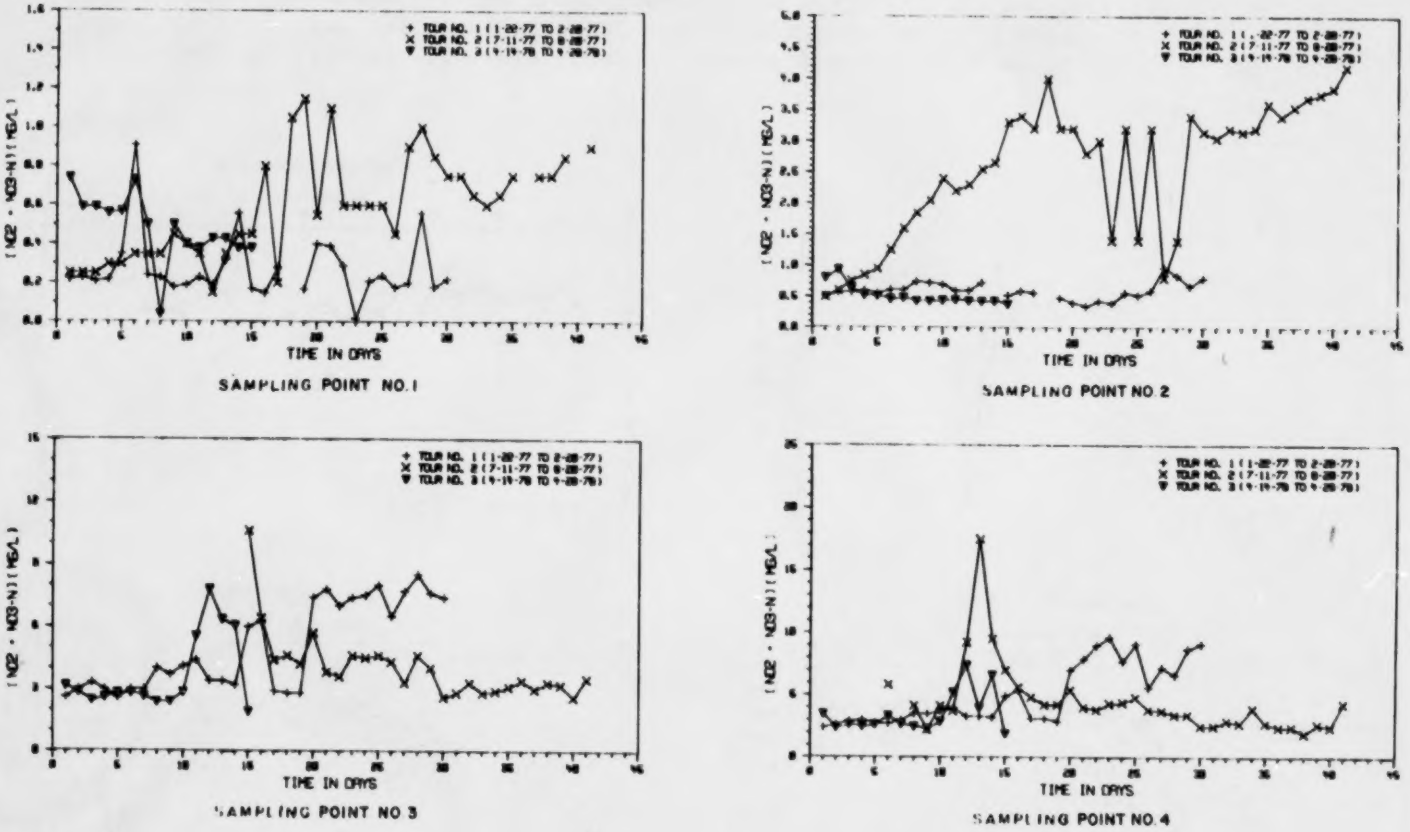

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Figure 27. The relationship observed between the combined values of nitrite and nitrate and time in days for the three tours at each of the four sampling points used to monitor the Mount Shasta water pollution control facility.

TABLE 15. NITROGEN MASS BALANCE FOR MT. SHASTA, CALIFORNIA

Tour Number and Sample Location	Mean Values for Three Sampling Periods mg N/l					Overall Reduction %
	NH_3-N	Org-N	NO_2-N	NO_3-N	Total-N	
Tour #1 (Jan. 22-Feb. 20)						
Lagoon Influent	10.59	3.9	0.069	0.21	14.8	-
Lagoon Effluent	7.55	3.3	0.041	0.56	11.5	22
Filter Effluent	3.95	2.0	0.035	5.0	11.0	26
Chlorinated Filter Effluent	3.91	1.9	0.013	5.0	10.8	27
Tour #2 (July 11-Aug. 20)						
Lagoon Influent	13.0	3.4	0.301	0.29	17.0	-
Lagoon Effluent	4.09	7.1	1.35	1.20	13.7	19
Filter Effluent	0.41	8.2	0.07	4.0	12.7	25
Chlorinated Filter Effluent	0.26	5.4	0.03	4.5	10.2	40
Tour #3 (April 14-April 28)						
Lagoon Influent	7.2	9.1	0.081	0.40	16.8	-
Lagoon Effluent	4.4	7.1	0.083	0.43	12.0	29
Filter Effluent	0.38	8.1	0.125	3.51	12.1	28
Chlorinated Filter Effluent	0.36	2.4	0.014	3.45	6.2	63

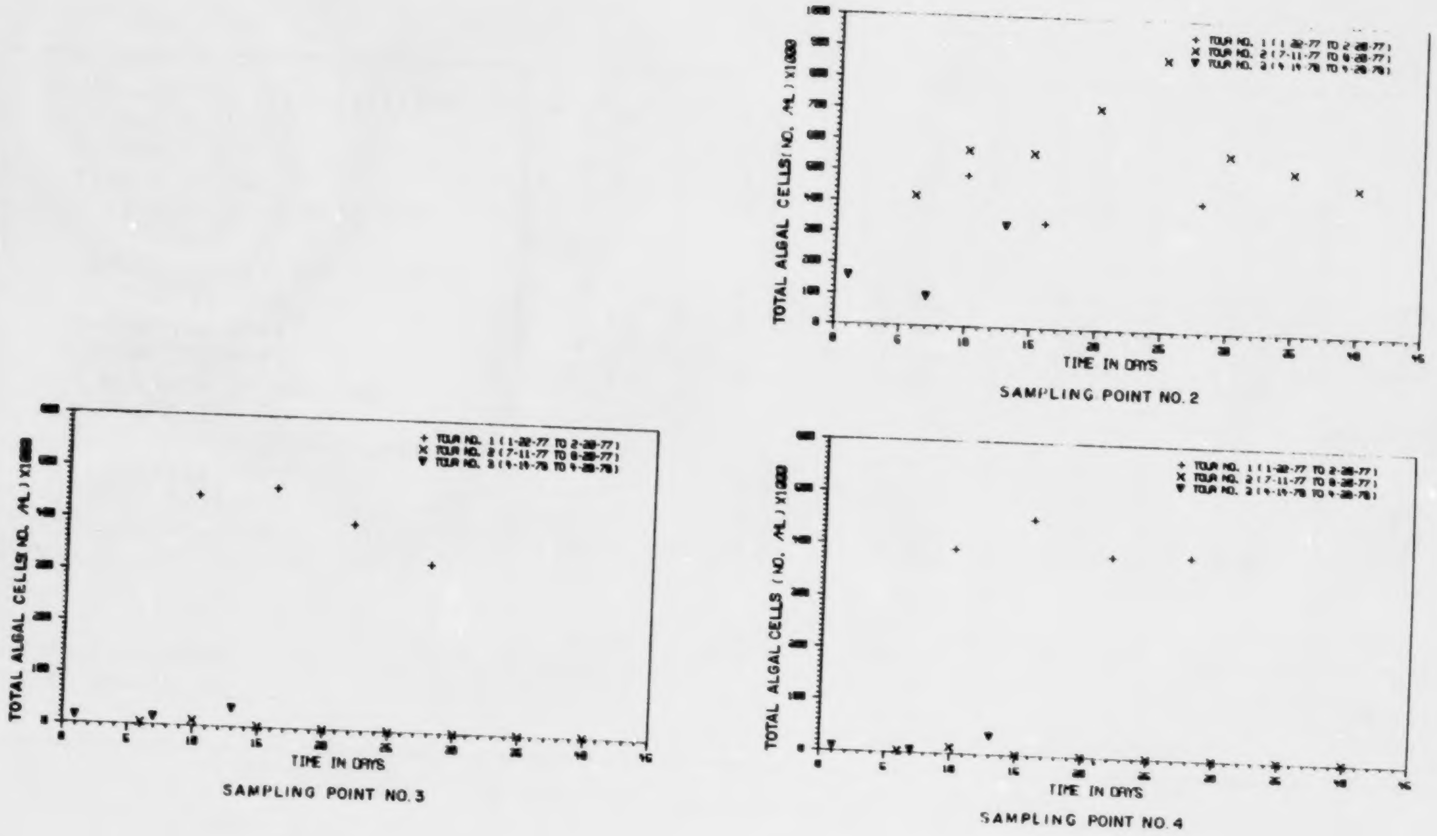

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Figure 28. The relationship observed between total number of algae cells and time in days for the three tours at the three sampling points used to monitor the Mount Shasta water pollution control facility.

TABLE 16. MT. SHASTA #2 LAGOON EFFLUENT

Tour #1	Sampling Dates							
Algal Genera	1/31/77	2/6/77	2/12/77	2/18/77				
Scenedesmus sp., cells/ml	15,680	392	MS	3,920				
Dictyosphaerium sp., cells/ml	466,481	331,240	MS	403,760				
Ankistrodesmus sp., cells/ml	3,920	5,880	MS	7,840				
Total Algae, cells/ml	486,081	337,512	MS	415,520				
Tour #2	Sampling Dates							
Algal Genera	7/16/77	7/20/77	7/25/77	7/30/77	8/4/77	8/9/77	8/14/77	8/19/77
Pediastrum sp., cells/ml	415,225	553,634	553,634	692,042	830,451	553,635	484,430	415,225
Closterium sp., cells/ml	769	384	-	-	-	-	-	-
Schroederia sp., cells/ml	384	-	1,153	3,076	7,689	1,538	384	308
Scenedesmus sp., cells/ml	1,922	11,534	-	-	769	7,689	19,223	26,913
Chlamydomonas sp., cells/ml	-	769	7,689	11,534	23,068	3,845	1,538	1,153
Diatom (Pennate), cells/ml	-	-	-	-	-	-	-	-
Micractinium sp., cells/ml	-	-	-	3,845	11,534	3,845	15,379	23,068
Dictyosphaerium sp., cells/ml	-	-	-	-	-	-	-	7,689
Total Algae, cells/ml	418,301	566,321	562,477	710,497	873,511	570,551	520,954	474,356
Tour #3	Sampling Dates							
Algal Genera	4/14/78	4/20/78	4/26/78					
Dictyosphaerium sp., cells/ml	53,312	56,448	178,752					
Diatoms								
Stephanodiscus sp., cells/ml	9,408	6,272	43,904					
Asterionella sp., cells/ml	-	-	25,088					
Scenedesmus sp., cells/ml	50,176	14,112	28,224					
Closterium sp., cells/ml	3,136	3,136	12,544					
Ankistrodesmus sp., cells/ml	3,136	1,568	6,272					
Chlamydomonas sp., cells/ml	12,544	4,704	6,272					
Schroederia sp., cells/ml	9,408	1,568	3,136					
Micractinium sp., cells/ml	15,680	7,840	25,088					
Total Algae, cells/ml	156,800	95,648	329,280					

MS = missing sample.

TABLE 16. MT. SHASTA #3 FILTER EFFLUENT

Tour #1	Sampling Dates							
Algal Genera	1/31/77	2/6/77	2/12/77	2/18/77				
Scenedesmus sp., cells/ml	15,680	7,840	3,920	11,760				
Dictyosphaerium sp., cells/ml	427,280	450,800	392,000	309,680				
Ankistrodesmus sp., cells/ml	1,960	3,920	1,960	3,920				
Total Algae, cells/ml	444,920	462,560	397,880	325,360				
Tour #2	Sampling Dates							
Algal Genera	7/16/77	7/20/77	7/25/77	7/30/77	8/4/77	8/4/77	8/14/77	8/14/77
Pediastrum sp., cells/ml	4,212	10,530	1,404	-	-	-	-	-
Closterium sp., cells/ml	-	78	-	-	-	-	-	-
Schroederia sp., cells/ml	-	-	-	-	-	-	-	74
Scenedesmus sp., cells/ml	702	-	-	-	-	-	-	-
Chlamydomonas sp., cells/ml	-	74	234	312	156	94	164	153
Diatom (Pennate), cells/ml	-	-	78	-	-	156	-	-
Micractinium sp., cells/ml	-	-	-	-	-	-	148	-
Dictyosphaerium sp., cells/ml	-	-	-	-	-	-	-	1,560
Total Algae, cells/ml	4,914	10,682	1,716	312	156	250	312	1,787
Tour #3	Sampling Dates							
Algal Genera	4/14/78	4/20/78	4/26/78					
Dictyosphaerium sp., cells/ml	10,819	11,290	19,757					
Diatoms								
Stephanodiscus sp., cells/ml	1,725	627	4,704					
Asterionella sp., cells/ml	-	-	-					
Scenedesmus sp., cells/ml	-	-	-					
Closterium sp., cells/ml	1,098	941	2,822					
Ankistrodesmus sp., cells/ml	627	627	941					
Chlamydomonas sp., cells/ml	627	1,568	1,568					
Schroederia sp., cells/ml	157	941	2,509					
Micractinium sp., cells/ml	-	-	3,763					
Total Algae, cells/ml	15,053	15,994	36,064					

TABLE 16. MT. SHASTA #4 CHLORINATED FILTER EFFLUENT

Tour #1	Sampling Dates							
Algal Genera	1/31/77	2/6/77	2/12/77	2/18/77				
Scenedesmus sp., cells/ml	342	7,840	1,960	392				
Dictyosphaerium sp., cells/ml	384,160	446,880	380,240	388,080				
Ankistrodesmus sp., cells/ml	7,840	7,840	3,920	392				
Total Algae, cells/ml	392,392	452,550	386,120	388,864				
Tour #2	Sampling Dates							
Algal Genera	7/16/77	7/20/77	7/25/77	7/30/77	8/4/77	8/4/77	8/14/77	8/14/77
Pediastrum sp., cells/ml	2,808	11,232	-	-	-	-	-	321
Closterium sp., cells/ml	-	70	-	-	-	-	-	-
Schroederia sp., cells/ml	78	55	62	-	86	62	78	-
Scenedesmus sp., cells/ml	-	-	-	-	-	-	-	-
Chlamydomonas sp., cells/ml	-	-	78	234	78	70	78	-
Diatom (Pennate), cells/ml	-	-	-	-	-	-	-	-
Micractinium sp., cells/ml	-	-	-	-	-	101	156	-
Dictyosphaerium sp., cells/ml	-	-	-	-	-	-	-	779
Total Algae, cells/ml	2,886	11,357	140	234	164	234	312	1,100
Tour #3	Sampling Dates							
Algal Genera	4/14/78	4/20/78	4/26/78					
Dictyosphaerium sp., cells/ml	1,725	314	14,112					
Diatoms:								
Stephanodiscus sp., cells/ml	3,763	941	3,763					
Asterionella sp., cells/ml	-	-	314					
Scenedesmus sp., cells/ml	157	1,882	4,077					
Closterium sp., cells/ml	1,254	627	3,136					
Ankistrodesmus sp., cells/ml	941	627	1,254					
Chlamydomonas sp., cells/ml	784	1,254	3,450					
Schroederia sp., cells/ml	627	314	314					
Micractinium sp., cells/ml	-	-	5,018					
Total Algae, cells/ml	9,251	5,958	35,437					

Table 17 presents a summary of the mean algal concentrations at the three sampling points for the three tours. A significant seasonal change in total algal concentrations in the lagoon system effluent can be observed with the largest concentration in the Summer (tour #2).

The intermittent sand filters did not effectively remove algal cells during tour #1. Although the removal was negligible during tour #1, Figure 28 indicates that there was a slight tendency to remove cells as time progressed. This failure to remove algal cells is again related to the frozen filters and shows that the lagoon effluent was bypassing the filter.

Algal cell removal during the last two tours was excellent and during tour #2 when the system was operated as specified, 99.6 percent of the algae applied were removed.

Flow Rate--

Figure 29 shows the flow rates measured at the facility influent and effluent sampling points (#1 and #4).

Influent flow rates for tours #1 and #2 did not fluctuate widely and the tour flow rates were 2,165 and 2,142 m^3/d, respectively. There was a significant increase in flow rate during tour #3 because of the wet Winter and Spring. During tour #3 the mean influent flow rate was 3444 m^3/d. The erratic discharge rates occurring during sampling periods #1 and #3 reflect the variations in the operating procedure used with the filters. During tour #2 the discharge flow rate was relatively consistent because of the operation of the filters to control the volume discharged. The mean effluent flow rates for tours #1, #2, and #3 were 2006, 1022, and 2650 m^3/d, respectively.

Because of the variations in the methods of operating the Mt. Shasta facility, it is not possible to calculate the loss of water as the wastewater passed through the system. During tour #1 the operator adjusted

TABLE 17. MEAN ALGAL CONCENTRATIONS, CELLS/ml

Sampling Location	Tour #1	Tour #2	Tour #3
Lagoon Effluent	413,000	587,000	194,000
Filter Effluent	408,000	2,520	22,400
Chlorinated Filter Effluent	405,000	2,050	16,900
Percent Removal	1.3	99.6	88.5

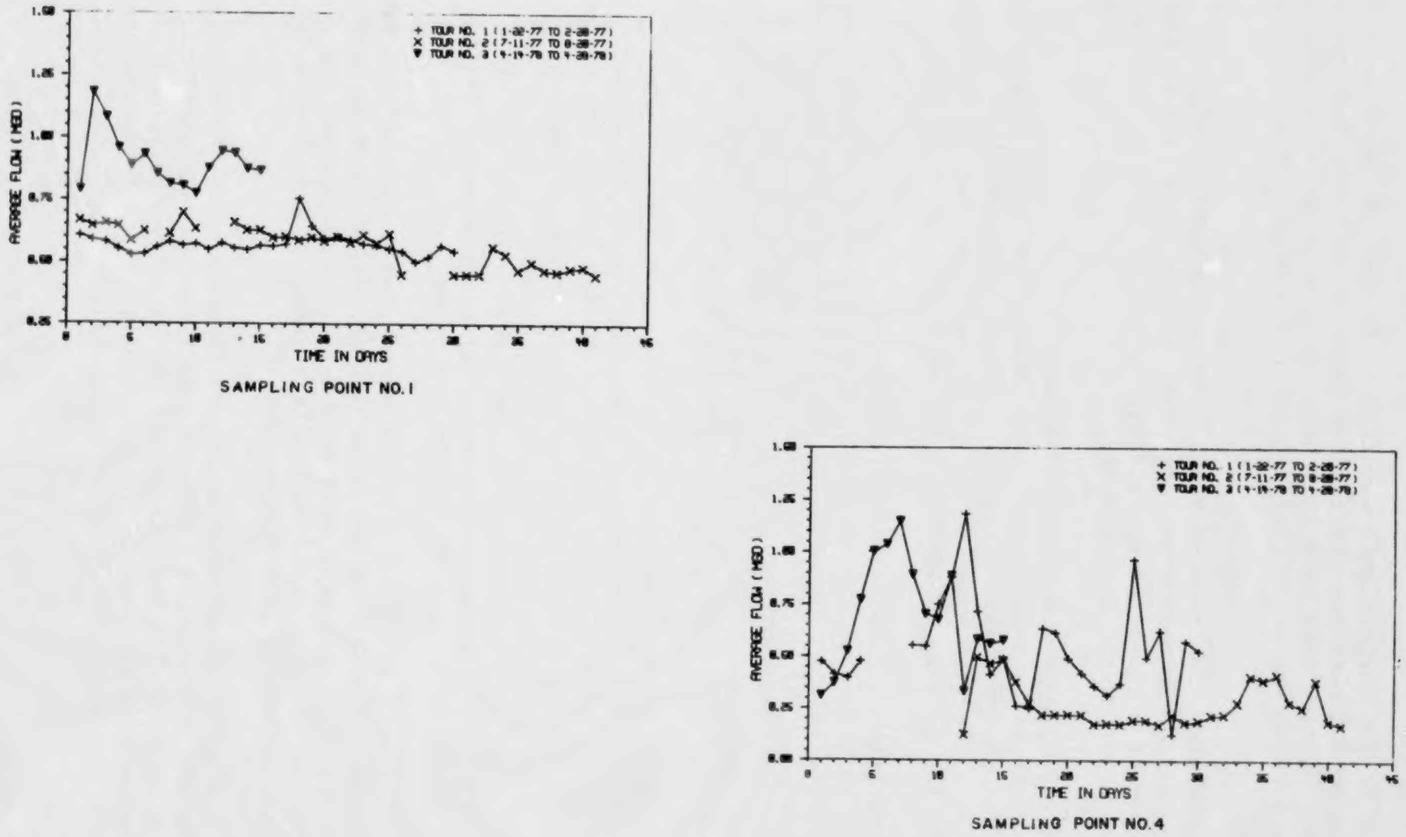

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Figure 29. The relationship observed between average daily flowrate and time in days for the three tours at the two sampling points used to monitor the Mount Shasta water pollution control facility (1 MGD = 3,785 m^3/day).

the discharge from the system to match the influent flow rate; therefore, the water levels in the lagoon system were constantly fluctuating.

During tour #2 the filters were modified to operate one half of a filter as a slow sand filter and the loading rates on both the slow and intermittent sand filters were held constant. This resulted in a much lower volume of water being discharged and water was stored in the lagoons during this tour.

The mean discharge flow rate of 2,627 m^3/d during tour #3 resulted from a wide fluctuation in discharge flow rates ranging from 1185 to 4349 m^3/d. The fluctuations were a result of operational variations made by the operator for various experimental arrangements.

24-Hour Composite Sample pH and Dissolved Oxygen--
The 24-hour composite samples collected at all four sampling stations were monitored for pH and dissolved oxygen. The results are shown in Figures 30 and 31. The variations in pH values and dissolved concentrations followed closely the in situ measurements but with less fluctuation.

Parallel Slow and Intermittent Sand Filtration--
General--As described in the observed O & M paragraphs, during tour #2 at Mt. Shasta one half of a filter was converted to operate as a slow sand filter to compare the performance with the intermittent sand filter operation. The results of this experiment are summarized in Table 18. The variation of the various parameters with time for both types of filters are presented in Figures B-1 through B-20 located in Appendix B.

Biochemical Oxygen Demand (BOD_5)--Figure B-1 and Table 18 show the variations in the BOD_5 concentrations with time for the slow sand filter operated in parallel with the intermittent sand filters during tour #2. The mean BOD_5 concentrations in the slow sand filter effluent was 3 mg/l, and the individual data points ranged from 1 mg/l to 7 mg/l. BOD_5 removals in the two parallel systems were comparable. The intermittent sand filter mean effluent BOD_5 concentration was 4 mg/l, and the mean influent BOD_5 concentration to both types of filters was 19 mg/l.

The parallel slow sand filter produced a comparable mean soluble BOD_5 concentration to that produced by the intermittent sand filters as shown in Table 18 and Figure B-2. The mean soluble BOD_5 concentration for the slow and intermittent filters was 3 mg/l with a range of 1 to 6 mg/l for the slow and 2 to 7 mg/l for the intermittent sand filter.

Suspended solids--The suspended solids performance with the parallel slow sand filter and comparable data for the intermittent sand filters are shown in Figure B-3. The mean suspended solids concentration of 15 mg/l was slightly higher than the mean of 13 mg/l observed for the intermittent sand filter; however, the diffference is not statistically significant (5 percent level).

Volatile suspended solids--The results of the parallel slow sand filter operation and comparative data for the intermittent sand filters are shown

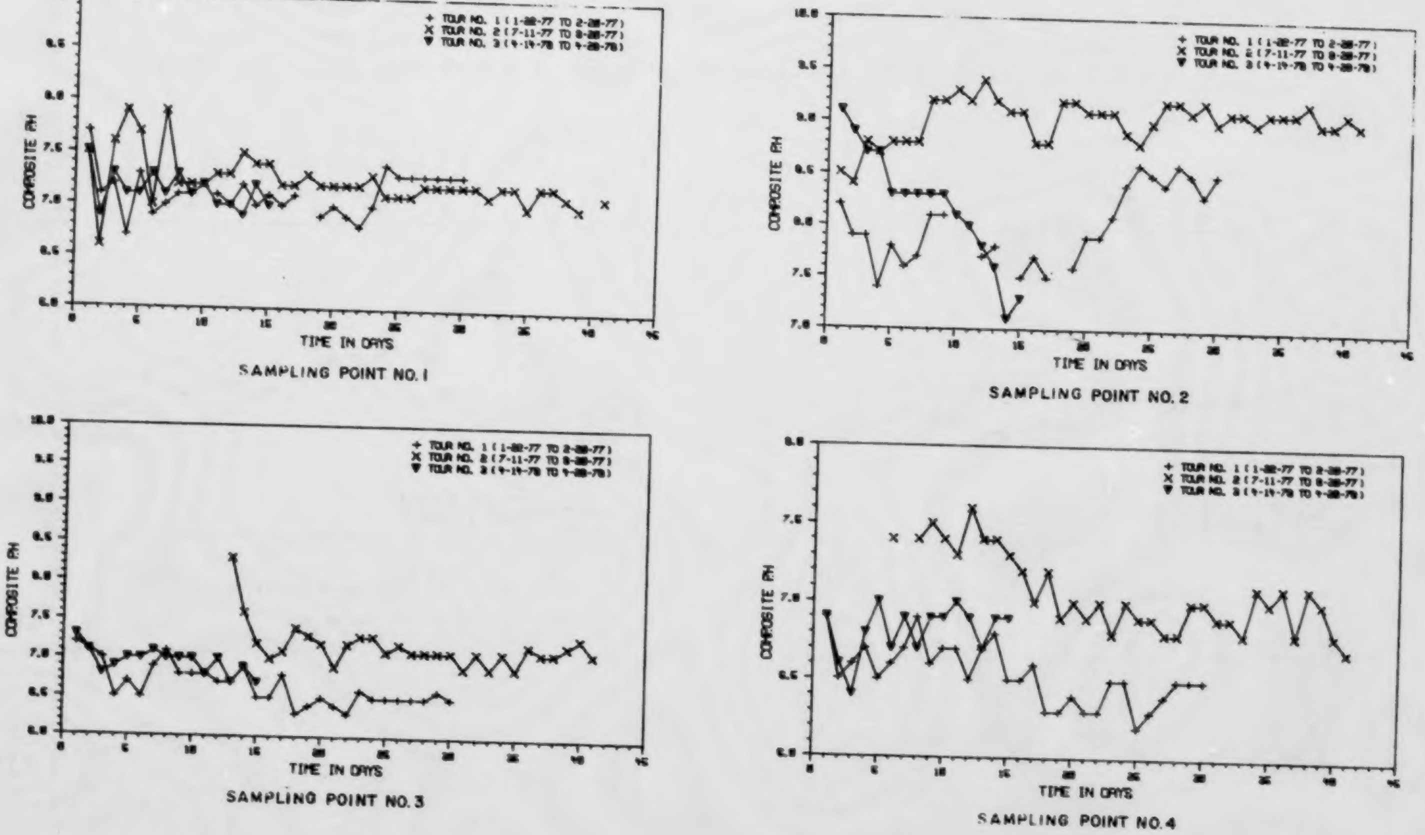


Figure 30. The relationship observed between composite pH and time in days for the three tours at each of the four sampling points used to monitor the Mount Shasta water pollution control facility.

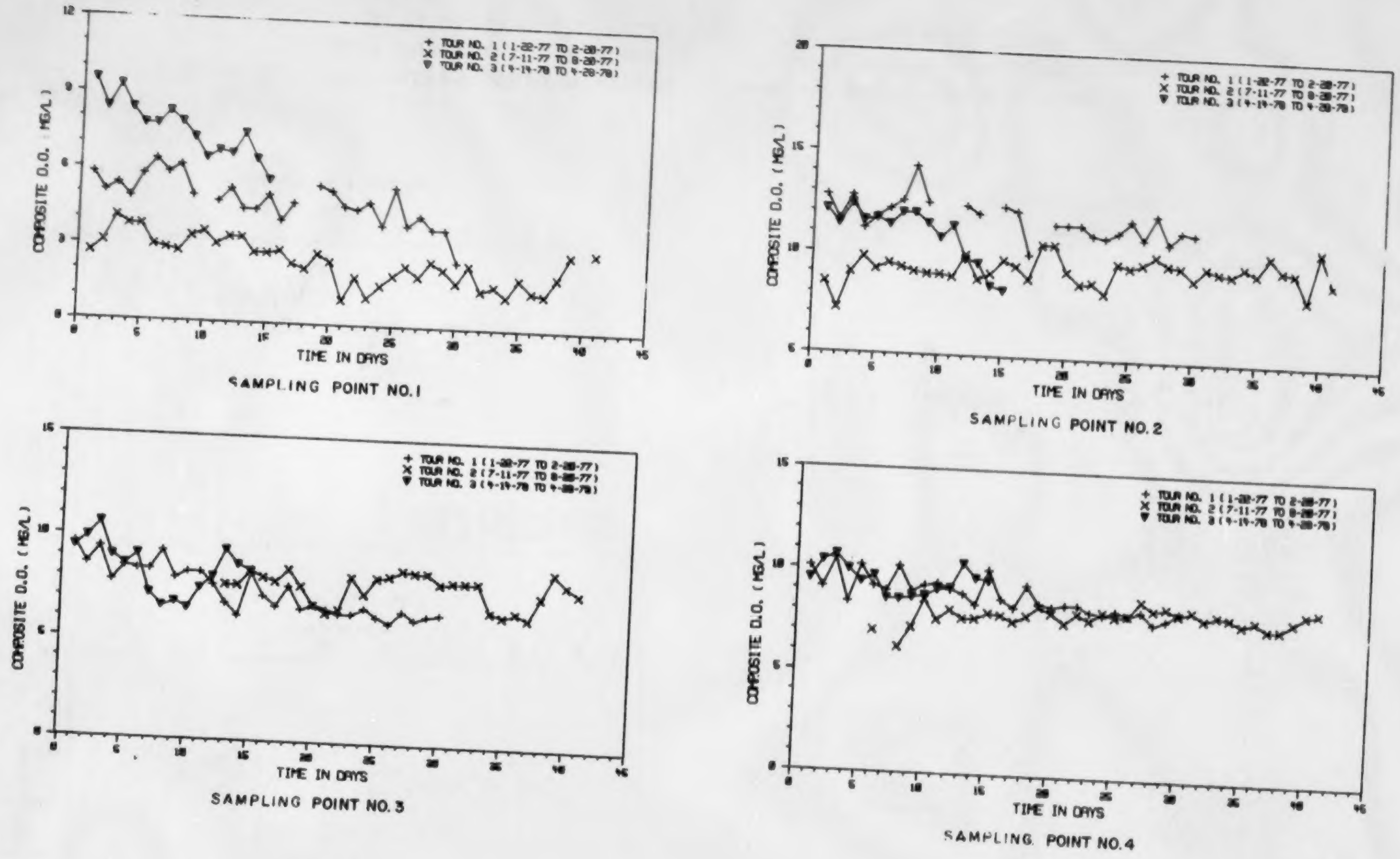


Figure 31. The relationship observed between composite dissolved oxygen and time in days for the three tours at each of the four sampling points used to monitor the Mount Shasta water pollution control facility.

TABLE 18. COMPARATIVE SUMMARY OF THE PARALLEL OPERATION OF INTERMITTENT SAND FILTERS AND SLOW SAND FILTERS AT MT. SHASTA DURING TOUR #2

Parameter	Influent to Filters			Intermittent Sand Filter			Slow Sand Filter		
	Range	Mean	S. Dev.	Range	Mean	S. Dev.	Range	Mean	S. Dev.
BOD$_5$(mg/ℓ)	9 - 31	19	6	2 - 7	4	1	1 - 7	3	1
Sol. BOD$_5$(mg/ℓ)	3 - 8	5	2	2 - 7	3	1	1 - 6	3	1
S.S. (mg/ℓ)	47 - 99	71	13	1 - 35	13	9	4 - 28	15	7
V.S.S. (mg/ℓ)	22 - 71	48	12	1 - 22	7	6	1 - 20	8	5
Fecal Col. (organisms/100 mℓ)	<1 -145	24	0.6140L	1 - 17	2	0.4466L	2 - 33	4	0.5169L
In situ pH (pH)	9.0 - 9.7	-	-	6.7 - 7.7	-	-	7.2 - 8.2	-	-
In situ Temp. (C°)	23 - 25.5	24	0.7	22 - 27	23.8	1.3	23 - 26	24.6	0.9
In situ D.O. (mg/ℓ)	9.0 - 13.5	11.6	1.2	5.1 - 6.9	6.1	0.4	1.9 - 6.5	5.1	1.3
COD (mg/ℓ)	30 -175	120	52	111 -148	129	10	25 -132	94	37
Sol. COD (mg/ℓ)	16 -172	112	57	101 -142	123	9	11 -132	88	40
Alkal. as CaCO$_3$ (mg/ℓ)	65 - 96	72	7	18 - 59	42	9	32 - 73	55	9
Total P (mg-P/ℓ)	4.52- 6.25	5.3	0.5	0.97- 5.44	3.8	1.0	1.65- 4.78	3.44	0.8
TKN mg-N/ℓ	9.2 - 12.9	11.4	1.2	6.4 - 11.1	8.6	1.5	6.9 - 10.6	9.2	1.0
NH$_3$ mg-N/ℓ	0.5 - 7.41	3.37	1.89	0.01- 1.32	0.41	0.35	0.01- 1.5	0.49	0.47
Org-N mg-N/ℓ	3.1 - 11.3	8.0	2.2	5.9 - 10.8	8.2	1.5	6.9 - 1.5	8.7	1.1
NO$_2$-N mg-N/ℓ	0.56- 2.06	1.55	0.40	0.01- 0.19	0.07	0.05	0.01- 0.73	0.09	0.18
NO$_3$-N mg-N/ℓ	0.69- 2.32	1.43	0.53	2.6 - 10.6	4.0	1.06	1.4 - 4.9	2.8	1.2

L = Log$_{10}$

S. Dev. = Standard Deviation

in Figure B-4. The mean volatile suspended solids concentration in the slow sand filter effluent was 8 mg/l with a range of 1 to 20 mg/l, and the intermittent sand filter mean concentration was 7 mg/l with a range of 1 to 22 mg/l. The performance of the two systems did not differ statistically at the 5 percent level of significance.

Fecal coliform--The parallel slow sand filter effluent contained a geometric mean fecal coliform concentration of 4 organisms/100 ml with a range of 2 to 33 organisms/100 ml. The fecal coliform removal with the intermittent sand filter was slightly better than the removal with the slow sand filter, but not statistically (5 percent level) different. The results obtained with both types of filter systems are shown in Figure B-5 and Table 18.

In situ pH, temperature and dissolved oxygen (DO)--Figures B-6 through B-8 show the variations with time of the pH value, temperature and DO concentrations in the slow and intermittent sand filter effluents. Basically there was little difference between the two types of effluents.

Other quality parameters--Chemical Oxygen Demand (COD), alkalinity, total phosphorus, TKN, ammonia-N, organic-N, nitrite-N, and nitrate-N concentrations were also measured in the effluents from both types of filters and the results are presented in Table 18 and in Figures B-9 through B-18. The pH values and DO concentrations in the two types of filter effluent composite samples are shown in Figure B-19 and B-20. Insignificant differences were observed when comparing the two types of effluents (5 percent level).

Summary--Based upon earlier experiences (Harris et al., 1977) it is unlikely that the quality of the effluents would have remained the same over an extended period of operation. The slow sand filter would be expected to produce less nitrification and contain less DO; however, in this brief comparison (two separate comparisons of <2 weeks each) both effluents were essentially of equal quality.

Moriarty, New Mexico

Sampling Points--

Sampling point #1 was located at the influent screw pump wet well. This sample provided monitoring of the raw wastewater prior to entering the treatment facility. The location of the sampling stations is shown in Figure 3. The second sampling location was at the common collection outlet to the two polishing ponds.

Location of the third sampling point was at the combination dosing basin and chlorine contact chamber. The sample was obtained at the diagonally opposite corner from the chlorinator discharge point. Sampling point #3 provided chlorinated lagoon effluent prior to the application of the effluent to the intermittent sand filters.

Sampling point #4 was located at the manhole at the end of the filter underdrain system prior to discharge into the dry stream. Because the filters were dosed automatically by the dosing siphon, an electronic sensing switch was installed to activate the sampler whenever water flowed in the underdrain and to inactivate the sampler when the filters were drained.

Summary of Results--

A summary of the results for the Moriarty wastewater treatment system is presented in Table 19. Results are presented by tour and sampling point, and the percentage removals obtained with each component of the system are also presented. Each of the parameters measured is discussed by sampling point locations in the following sections.

Total Biochemical Oxygen Demand (BOD_5)--

Mean total BOD_5 concentrations for all sampling points and tours at Moriarty are presented in Table 19. The daily fluctuations of the total BOD_5 are presented in Figure 32.

Sampling point #1--During tours #1 and #2 mean concentrations were essentially the same at 133 and 135 mg/l, and during tour #3 an increase in mean BOD_5 to 177 mg/l was experienced. The variation in BOD_5 concentration with time is shown in Figure 32.

Sampling point #2--Performance of the lagoon system was consistent during each tour with tours #1 and #3 having similar means of 35 and 32 mg/l. Some fluctuations in BOD_5 concentrations were experienced during tours #1 and #3. Tour #1 fluctuations were caused by two Daphnia blooms in the lagoon system. Tour #3 fluctuations were apparently related to seasonal changes in the lagoon system. Tour #2 BOD_5 values remained consistent and resulted in a mean concentration of 22 mg/l.

Sampling point #3--Chlorinated lagoon effluent was collected at sampling point #3, and the results show the same characteristics as were discussed for sampling point #2. A slight increase in BOD_5 concentrations occurred and is probably related to the location of the sample intake near the bottom of the dosing basin. This arrangement may have resulted in the collection of carbonaceous material from the basin bottom settlings (Figure 32).

Sampling point #4--During tours #1 and #3 the filter effluent quality fluctuated with the variations in lagoon effluent quality as mentioned for sampling points #2 and #3. The mean BOD_5 concentrations for tours #1 and #3 were 20 and 21 mg/l. The most consistent and lowest mean BOD_5 concentration (10 mg/l) of the three sampling periods was measured during tour #2. The increase in performance can be related to a combination filter cleaning, changes in operational mode and the consistent and relatively lower applied BOD_5 concentration.

Biochemical oxygen demand (BOD_5) with nitrification inhibitors--

Figure 33 presents the BOD_5 concentrations measured with and without nitrification inhibitor for the three tours. BOD_5 measurements with inhibitor were performed only on two samples during the first two tours and only on one sample the third tour due to inadequate incubator space caused by

TABLE 19. SUMMARY OF RESULTS OBTAINED AT THE MORIARTY, NEW MEXICO, WASTEWATER TREATMENT SYSTEM

Parameter	Tour Number	Lagoon Influent Sampling Point #1	Lagoon Effluent Sampling Point #2		Filter Effluent Sampling Point #3		Chlorinated Filter Effluent Sampling Point #4		Overall Removal
		Concentration mg/ℓ	Concentration mg/ℓ	Removal %	Concentration mg/ℓ	Removal %	Concentration mg/ℓ	Removal %	%
Total BOD$_5$	1	133	35	74	37	-	20	46	85
	2	135	22	84	24	-	10	58	93
	3	177	32	82	38	-	21	45	88
Soluble BOD$_5$	1	81	25	69	31	-	21	32	74
	2	58	9	84	11	-	9	18	84
	3	82	18	78	26	-	17	35	79
Suspended Solids	1	174	83	52	68	18	23	74	87
	2	128	89	30	91	-	15	84	88
	3	155	71	54	72	-	8	89	95
Volatile Suspended Solids	1	136	65	52	51	22	15	71	90
	2	94	70	26	71	-	7	90	93
	3	124	58	53	56	3	5	91	96
Fecal[a] Coliform	1	3.97×10^6	27	99.99	1.8	93.33	8	-	99.99
	2	6.70×10^6	782	99.99	51	93.48	91	-	99.99
	3	2.03×10^6	62	99.99	1.3	97.90	2.3	-	99.99
pH[b] In Situ	1	7.9 (7.7 - 8.2)	8.9 (8.5 - 9.4)	-	8.8 (8.3 - 9.3)	-	8.0 (7.5 - 8.5)	-	-
	2	8.0 (7.9 - 8.2)	8.9 (8.7 - 9.1)		8.8 (8.5 - 9.1)		8.1 (7.9 - 8.3)	-	-
	3	8.2 (7.9 - 8.5)	8.9 (8.1 - 9.2)	-	8.9 (8.7 - 9.2)	-	7.9 (7.7 - 8.2)	-	-

continued

TABLE 19. CONTINUED

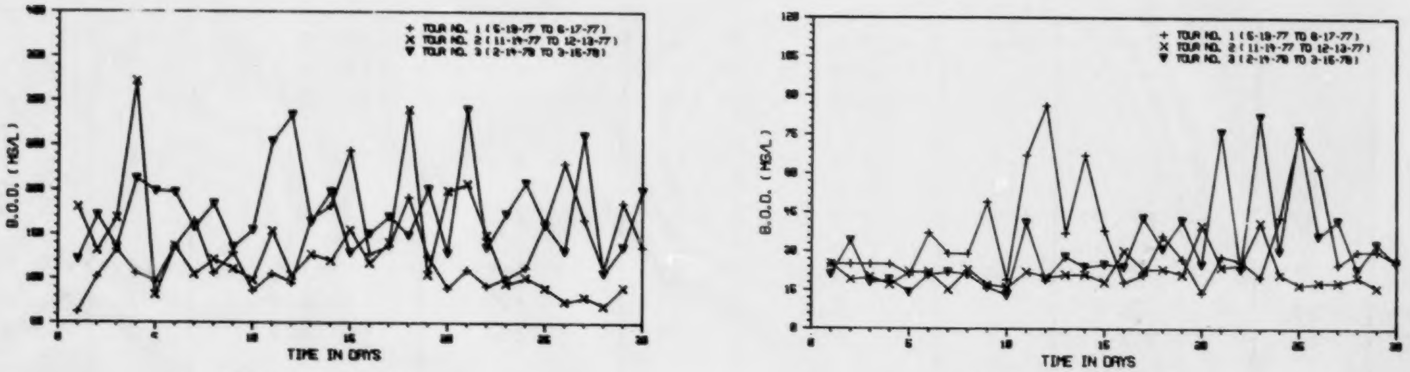
Parameter	Tour Number	Lagoon Influent Sampling Point #1	Lagoon Effluent Sampling Point #2		Filter Effluent Sampling Point #3		Chlorinated Filter Effluent Sampling Point #4		Overall Removal
		Concentration mg/ℓ	Concentration mg/ℓ	Removal %	Concentration mg/ℓ	Removal %	Concentration mg/ℓ	Removal %	%
Temperature[c] In Situ	1	21.5	20.4	-	20.4	-	20.3	-	-
	2	12.3	8.0	-	7.6	-	8.3	-	-
	3	14.2	8.1	-	8.3	-	8.1	-	-
Dissolved Oxygen In Situ	1	0.7	7.5	-	6.0	-	6.3	-	-
	2	3.2	12.0	-	11.7	-	9.4	-	-
	3	1.4	13.3	-	12.8	-	9.1	-	-
Total COD	1	369	144	61	143	1	93	35	75
	2	269	64	76	37	42	20	46	93
	3	276	45	84	29	36	17	41	94
Soluble COD	1	167	109	35	110	-	78	29	53
	2	216	56	74	28	50	13	54	94
	3	209	35	83	21	40	11	48	95
Alkalinity	1	428	257	40	265	-	246	7	43
	2	429	277	35	279	-	236	15	45
	3	451	344	24	348	-	297	15	34
Total Phosphorus	1	8.81	2.59	71	2.75	-	1.94	29	78
	2	10.23	4.61	55	4.40	5	2.65	40	74
	3	11.97	4.88	59	4.91	-	3.82	22	68
Flow[d] Rate	1	0.035	-	-	0.038	-	-	-	-
	2	0.092	-	-	0.050	-	-	-	46
	3	0.100	-	-	0.050	-	-	-	50

[a] Expressed in organisms/100 mℓ.

[b] Expressed as geometric mean in pH units (range of values).

[c] Expressed in °C.

[d] Expressed in million gallons/day.



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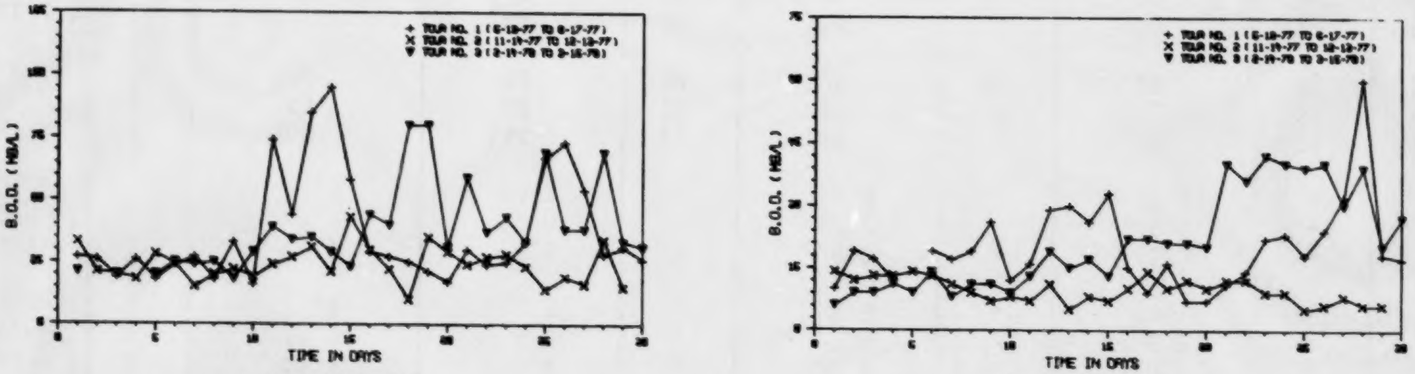

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Figure 32. The relationship observed between biochemical oxygen demand and time in days for the three tours at each of the four sampling points used to monitor the Moriarty wastewater treatment facility.

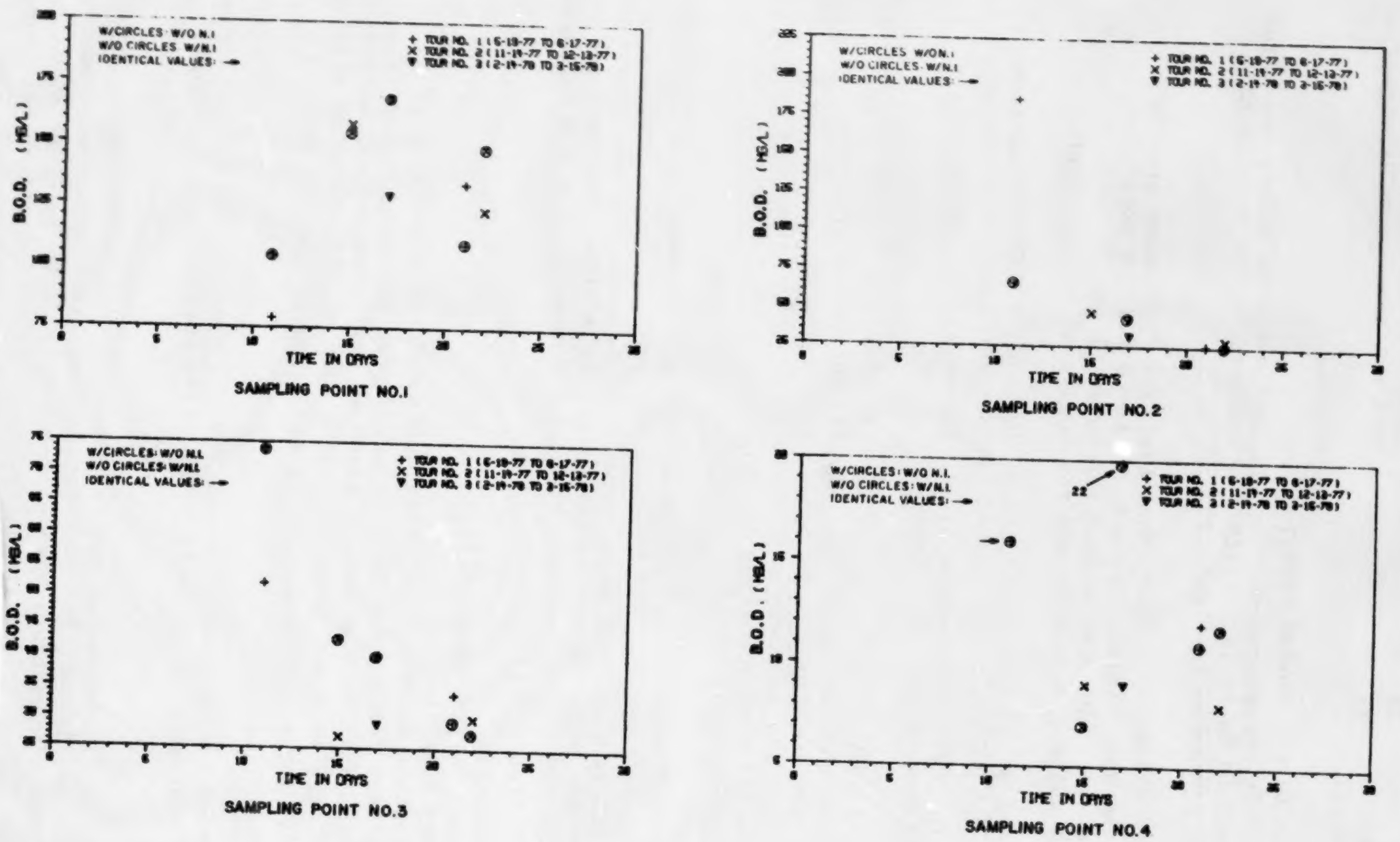


Figure 33. The relationship observed between biochemical oxygen demand and biochemical oxygen demand with nitrification inhibitor for those days during the three tours when simultaneous analysis was performed to monitor the Moriarty wastewater treatment facility.

the failure of one unit. In general at BOD_5 concentrations above 30 mg/l, inhibition was observed, but the differences were not statistically significant (1 percent level).

Soluble Biochemical Oxygen Demand (BOD_5)--

Mean soluble BOD_5 concentrations for all four sampling points and three tours are summarized in Table 19. Daily fluctuations in the soluble BOD_5 concentrations are presented in Figure 34.

Sampling point #1--Soluble BOD_5 concentrations fluctuated greatly, and the fluctuations were similar to those observed for the total BOD_5 variations (Figure 34). The mean values for tours #1 and #3 were 81 and 82 mg/l, and the mean value for tour #2 was the lowest at 58 mg/l (Table 19).

Sampling points #2 and #3--Fluctuations in soluble BOD_5 during tours #1 and #3 for both sampling points #2 and #3 reflect the same causes as mentioned for total BOD_5. The best performance by the lagoon system for the three tours was observed during tour #2 (Figure 34).

An increase in soluble BOD_5 similar to that observed for the total BOD_5 was observed at sampling point #3. The reason for the increase may be related to the location of the sampling inlet as mentioned above. It is also possible that the increase was caused by the chlorination of the algae laden lagoon effluent resulting in lysing of cells (Johnson et al., 1978 and Echelberger et al., 1971).

Sampling point #4--The filter effluent mean soluble BOD_5 concentrations were 21 (tour #1), 9 (tour #2), and 17 (tour #3) mg/l. Soluble BOD_5 removals by the intermittent sand filters were temperature related, and the lowest reduction of 18 percent occurred during the Winter (tour #2). However, the effluent quality was the highest at this time with a mean soluble BOD_5 concentration of 9 mg/l (Table 19).

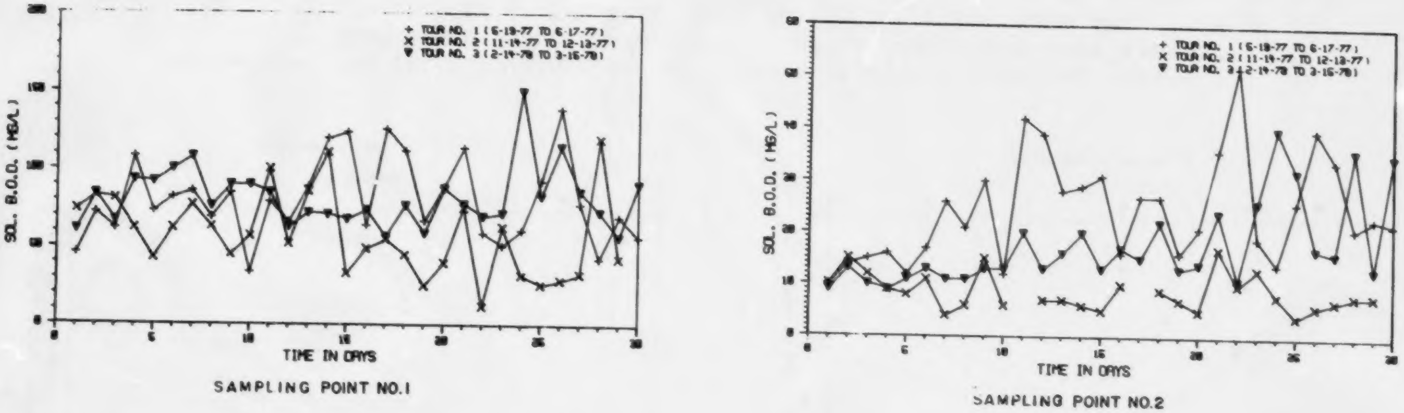
Soluble Biochemical Oxygen Demand (BOD_5)
with Nitrification Inhibitors--

The nitrification inhibitor allyl-thiourea did not significantly (1 percent level) affect the soluble BOD_5 values during the three tours (Figure 35). The concentrations were generally below 40 mg/l, but the concentrations greater than 100 mg/l were not affected. This lack of effect on the soluble BOD_5 may be attributable to the more rapid oxidation of soluble BOD.

Suspended Solids--

Mean suspended solids concentrations for all sampling points and tours at Moriarty are presented in Table 19. The daily variations are shown in Figure 36.

Sampling point #1--Suspended solids concentrations in the raw wastewater were fairly consistent, but some outstanding fluctuations were observed (Figure 36). These fluctuations were probably related to periodic discharges of one of the six lift stations in the Moriarty collection system resulting in a "slug" of solids being discharged when the pump was repaired. The lowest



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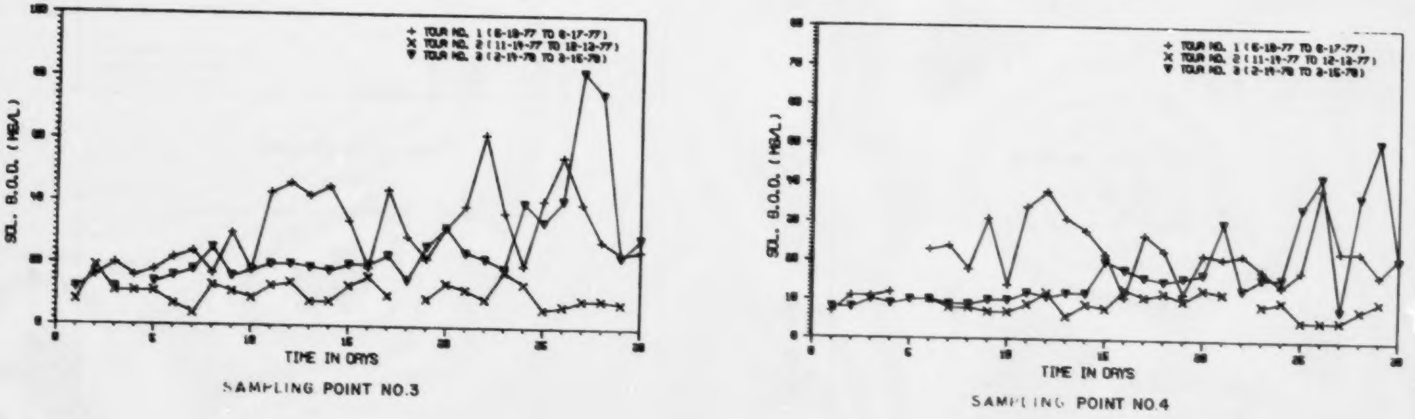

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Figure 34. The relationship observed between soluble biochemical oxygen demand and time in days for the three tours at each of the four sampling points used to monitor the Moriarty wastewater treatment facility.

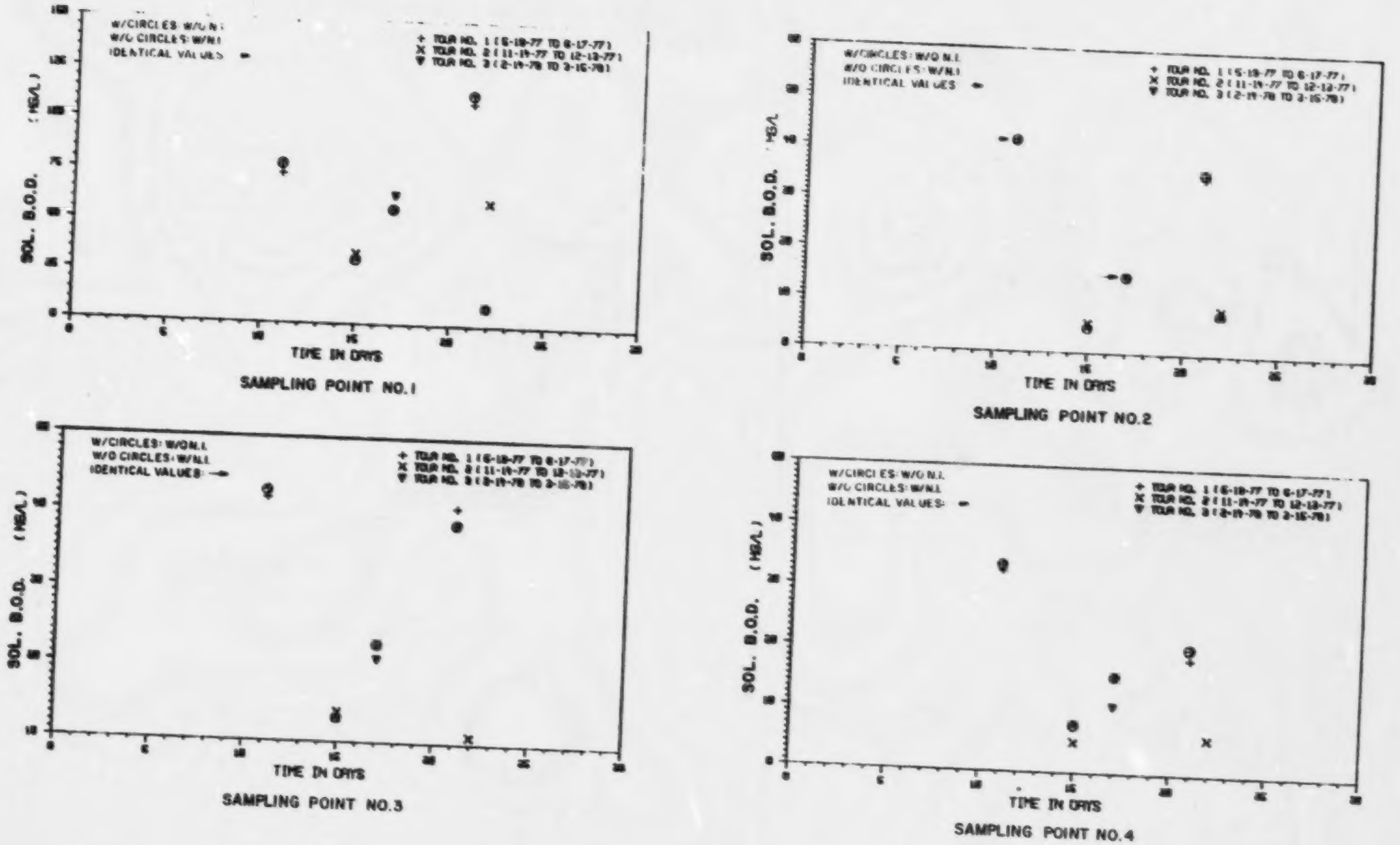


Figure 35. The relationship observed between soluble biochemical oxygen demand and soluble biochemical oxygen demand with nitrification inhibitor for those days during the three tours when simultaneous analysis was performed to monitor the Moriarty wastewater treatment facility.

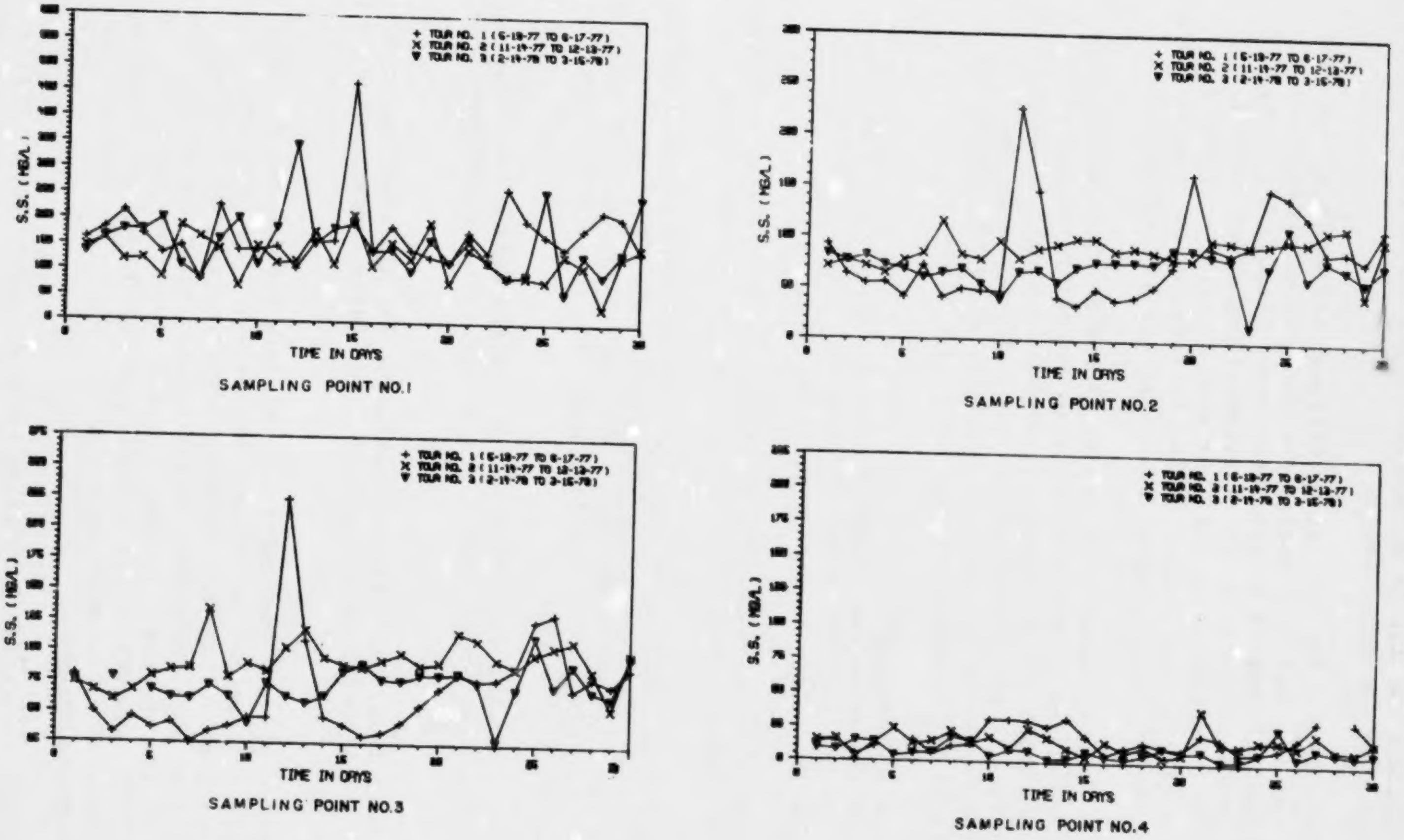


Figure 36. The relationship observed between suspended solids and time in days for the three tours at each of the four sampling points used to monitor the Moriarty wastewater treatment facility.

mean concentration of 128 mg/l was observed during tour #2, but excluding the wide fluctuations, there was little difference in the suspended solids concentrations measured during the three tours.

Sampling points #2 and #3--The lagoon effluent suspended solids concentrations were fairly consistent except for the periods during tour #1 when the *Daphnia* blooms occurred as mentioned above (Figure 36). The suspended solids concentrations in the chlorinated lagoon effluent were similar to those in the lagoon effluent, but with a slight decrease in concentration. The decline was related to the location of the sampler intake which would be below the highest algae concentrations most of the time.

Sampling point #4--An increase in suspended solids removal with time can be seen in the progressive decrease in the mean concentrations of effluent solids from 23 mg/l (tour #1) to 15 mg/l (tour #2) to 8 mg/l (tour #3). There was little difference in the concentrations of solids added to the filters; therefore, the difference is probably attributable to better removal of the type solids produced in the lagoon during the cold months.

Volatile Suspended Solids (VSS)--

The mean volatile suspended solids concentrations for all sampling points and tours at Moriarty are shown in Table 19. Daily variations in the volatile suspended solids concentrations are shown in Figure 37.

Sampling point #1--The infrequent discharges by the pumping stations accounted for the surges in VSS concentrations in the raw wastewater.

Sampling points #2 and #3--The high value of 227 mg/l observed during tour #1 at day 12 reflects the high *Daphnia* population. The suspended solids on day 12 were 96 percent volatile matter. Although sampling point #3 portrays more fluctuation than observed at sampling point #2, the overall mean is essentially the same (Table 19).

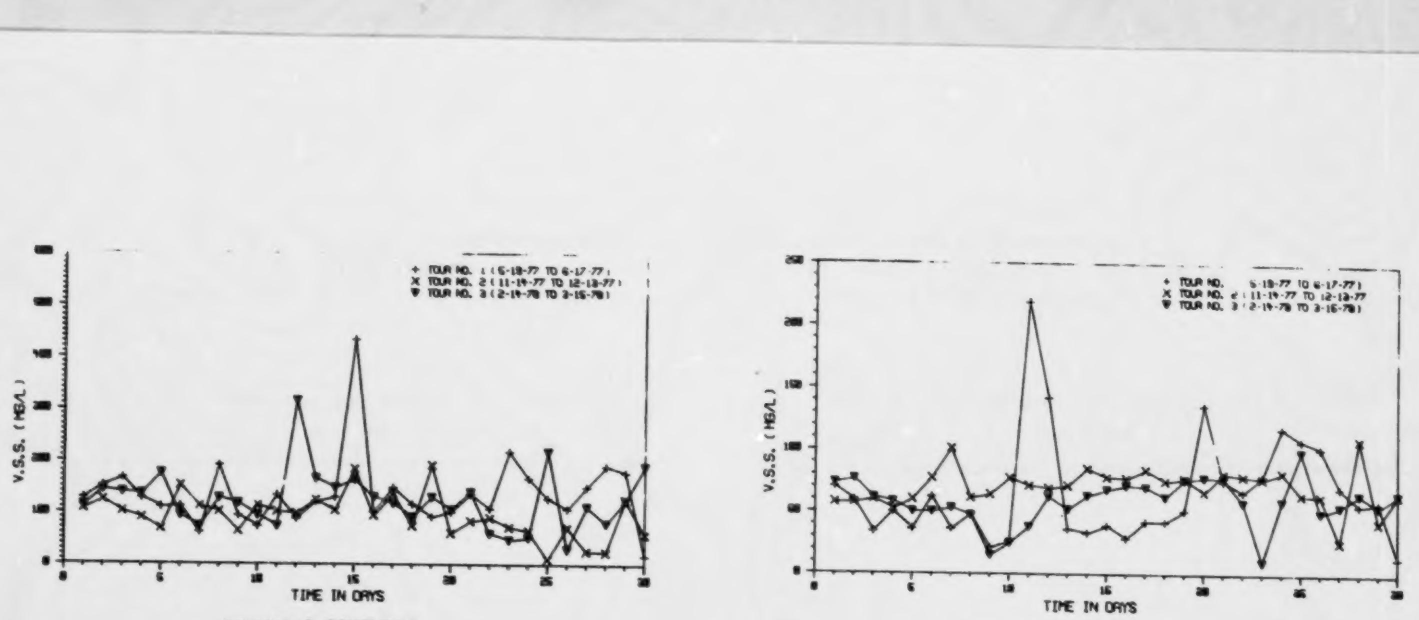
Sampling point #4--The volatile suspended solids during the three tours were consistent with only slight variations attributable to the *Daphnia* blooms.

Fecal Coliform--

Geometric mean fecal coliform concentrations for all sampling points and tours at Moriarty are presented in Table 19. The daily concentrations are shown in Figure 38.

Sampling point #1--The influent fecal coliform populations for the three tours indicate seasonal variations (Figure 38). The greatest fluctuations were experienced during tour #1 and the reasons for the fluctuations were the operational problems caused by the recent completion of the facility and the fact that many of the lift stations only pumped out every four or five days. Also tour #1 occurred at the beginning of Summer and the increased temperatures caused an increase in bacterial activity. The mean for tour #1 was 3,972,000 organisms/100 ml.

Fecal coliform concentrations during tours #2 and #3 varied little throughout the entire sampling periods with respective means of 6,717,000 and 2,032,000 organisms/100 ml.



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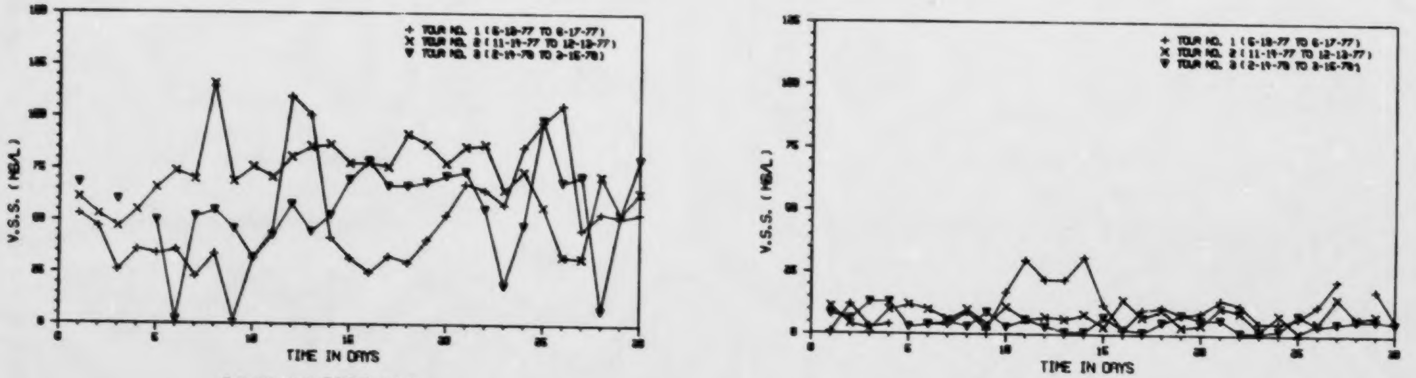

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Figure 37. The relationship observed between volatile suspended solids and time in days for the three tours at each of the four sampling points used to monitor the Moriarty wastewater treatment facility.

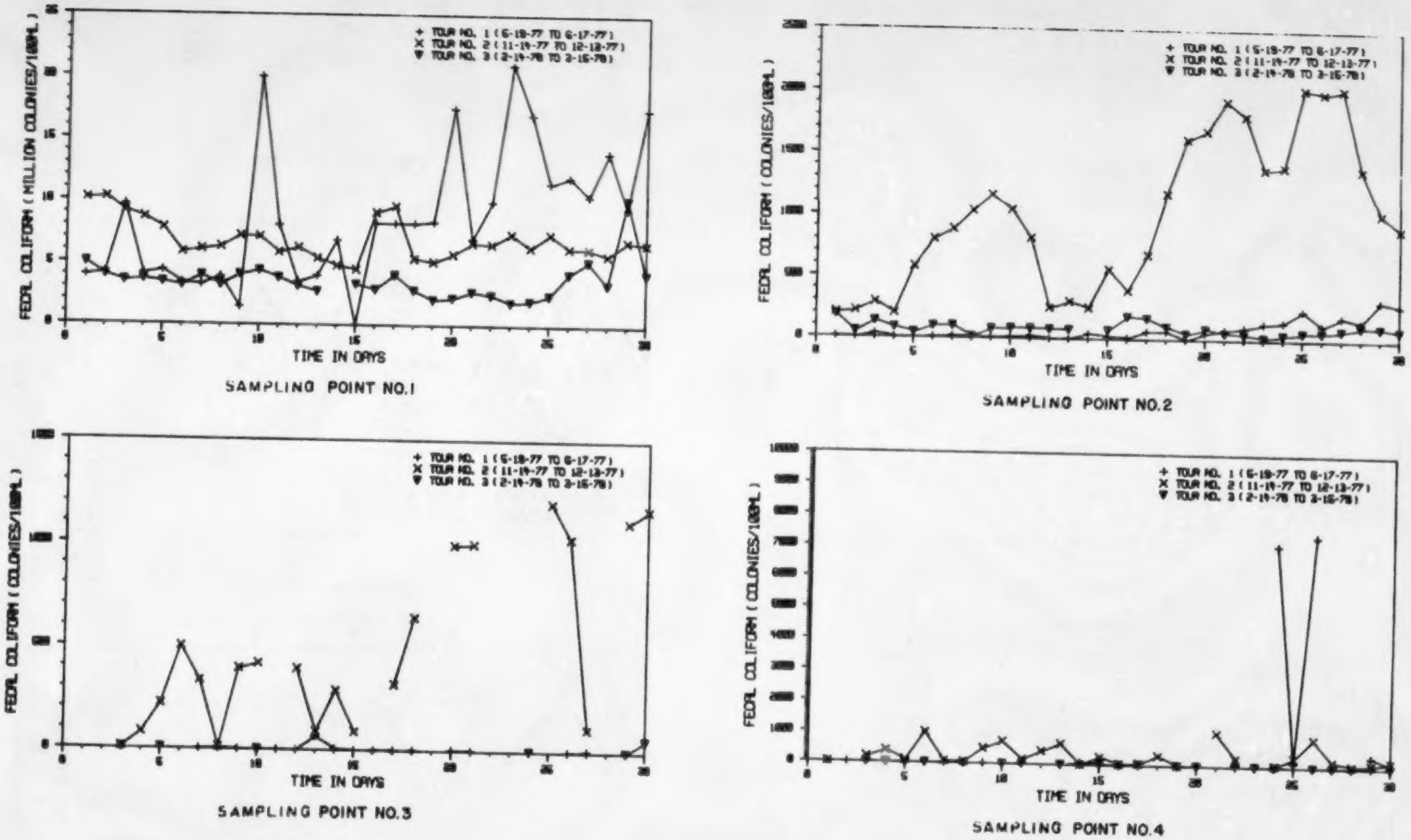


Figure 38. The relationship observed between fecal coliform bacteria and time in days for the three tours at each of the four sampling points used to monitor the Moriarty wastewater treatment facility.

Sampling point #2--During the first and third sampling period, low fecal coliform concentrations were observed in the lagoon system effluent and the means were 27 and 62 organisms/100 ml, respectively (Figure 38). The fecal coliform populations in the lagoon effluent during these two tours varied little and 99.999 percent removal of the fecal coliform bacteria was observed.

During tour #2 in the late Fall, a relatively large fecal coliform population in the lagoon effluent (200-2,000 organisms/100 ml) fluctuated without any evident cause. The lagoon system still provided a 99.99 percent reduction in the fecal coliform bacteria.

Sampling point #3--The chlorination system effectively removed the fecal coliform becteria when in operation (Figure 38). During tours #1 and #3 continuous chlorination of the lagoon effluent was practiced, and the geometric mean concentration was <2 organisms/100 ml for the two periods and the range of individual values was <1 to 64 organisms/100 ml. For 16 days of the 30-day sampling period of tour #1, the fecal coliform concentration was <1 organism/100 ml, and during tour #3 there were 24 days with a count of <1 organism/100 ml.

Periodic fluctuations during tour #2 were caused by the experimentation to determine the effects of chlorination of the wastewater prior to application to the sand filters. Other than the increased concentration of fecal coliform in the water applied to the filters when chlorination was stopped, little difference was observed in filter performance or in filter service life.

Sampling point #4--The intermittent sand filter effluent fecal coliform concentrations were higher than the concentration in the applied water over 50 percent of the 90 sampling days during the three tours (Figure 38). The cause for this apparent regrowth of fecal coliform in the underdrain system is unknown; however, regrowth is not uncommon in most natural systems. The large concentrations at the end of tour #1 coincide with an occurrence of a Daphnia bloom, but it is unlikely that this affected the regrowth of fecal coliform bacteria.

In Situ pH, Temperature, Dissolved Oxygen--

Mean in situ pH values, temperatures, and dissolved oxygen concentrations for all sampling locations and tours at Moriarty are presented in Table 19. The daily values for the pH values, temperatures, and dissolved oxygen concentrations are plotted versus time in Figures 39, 40, and 41.

Sampling point #1--The pH value of the raw wastewater remained consistent with a range of 7.7 to 8.5 for the individual values (Figure 39).

Temperature followed a seasonal variation dependent on the time of year (Figure 40). During the first tour in late Spring, the mean temperature was 21.5°C. The second two tours were during the colder seasons and mean temperatures were 12.3°C for tour #2 and 14.2°C for tour #3.

As discussed earlier, many of the lift stations in the collection system only pumped periodically and the wastewater was generally devoid of

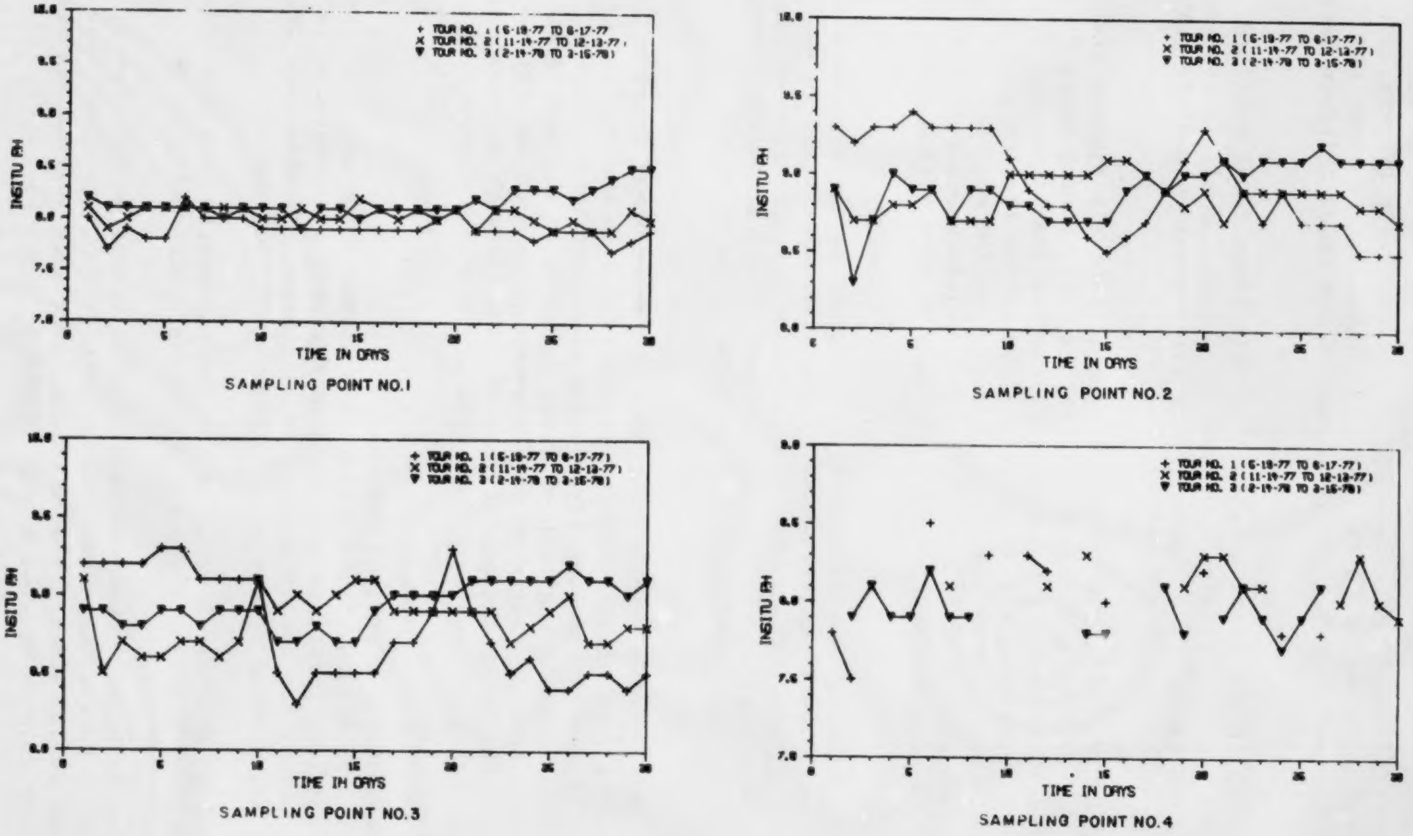
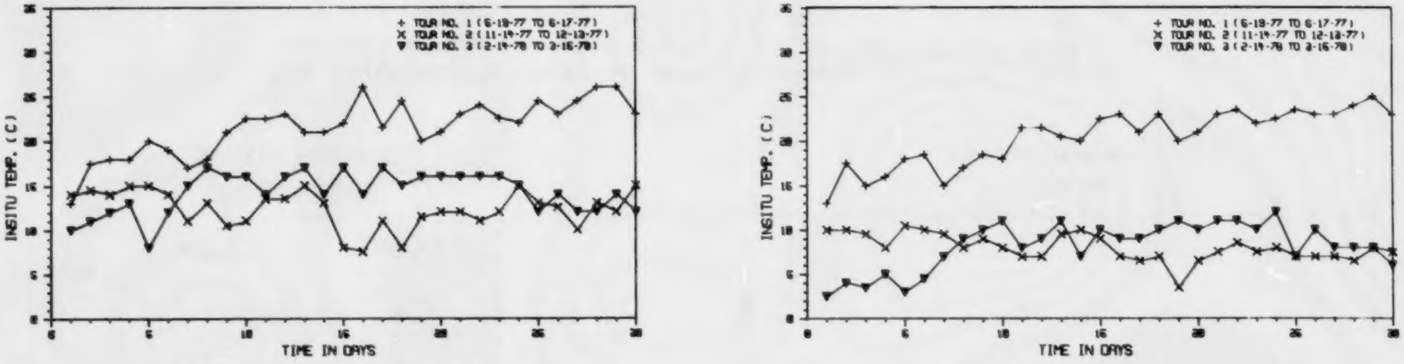


Figure 39. The relationship observed between in situ pH and time in days for the three tours at each of the four sampling points used to monitor the Moriarty wastewater treatment facility.



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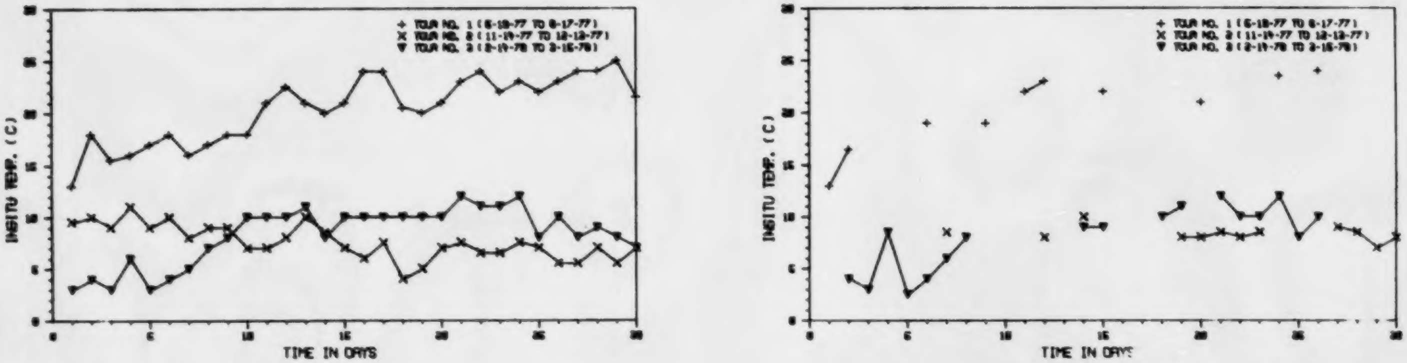

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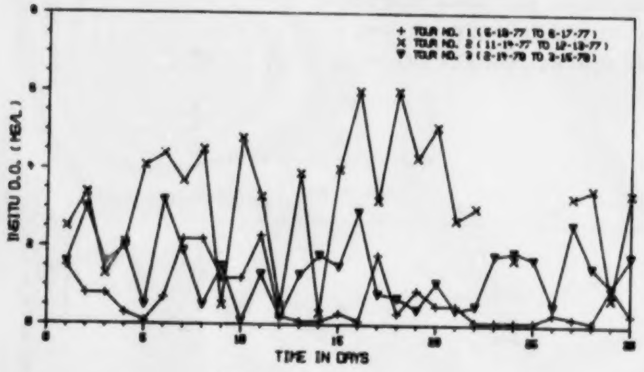
Figure 40. The relationship observed between in situ temperature and time in days for the three tours at each of the four sampling points used to monitor the Moriarty wastewater treatment facility.



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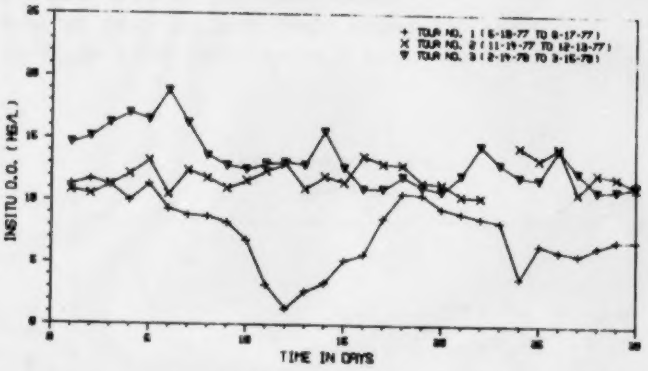

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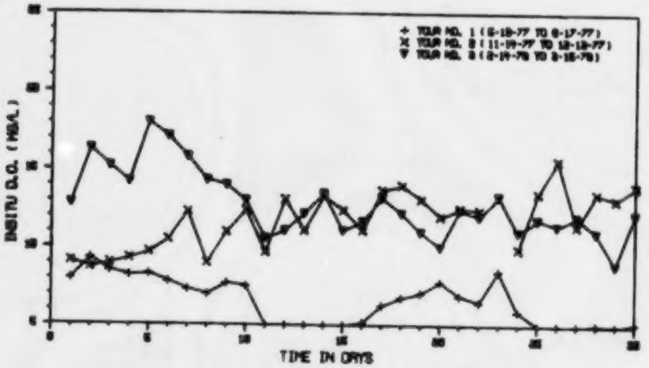

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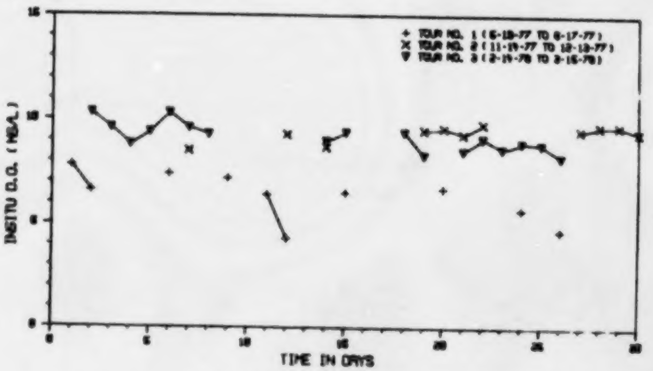


SAMPLING POINT NO. 4

Figure 41. The relationship observed between in situ dissolved oxygen and time in days for the three tours at each of the four sampling points used to monitor the Moriarty wastewater treatment facility.

dissolved oxygen. This characteristic of the influent is illustrated in Figure 41 by the dissolved oxygen fluctuations observed at sampling point #1.

Sampling points #2 and #3--Chlorination did not affect the pH value, temperature or dissolved oxygen concentration in the in situ samples. Therefore, the graphs of the parameters at the two sampling points are very similar and can be discussed as three sets of data (Figures 39, 40 and 41).

The temperatures for the last three sampling points were consistent within each sampling period. The highest mean temperature of 20.4 C was measured during tour #1 in late Spring. Mean temperatures during tours #2 and #3 were the same at 8°C. Tours #2 and #3 represent the coldest periods of the year.

The dissolved oxygen concentrations in the lagoon effluent were relatively consistent for tours #2 and #3 with respective means of 12.0 and 13.3 mg/l. During tour #1 more drastic variations in dissolved oxygen concentrations were observed, and these variations were induced by the Daphnia blooms consuming the algal populations. Chlorination produced a slight decrease in the dissolved oxygen in the lagoon effluent.

Sampling point #4--The in situ monitoring of this sampling point was dependent upon being around when the filters were dosed. Sometimes this was late evening or early morning; thus, the reason for the missing data on Figures 39, 40 and 41. The pH value and dissolved oxygen concentrations in the lagoon effluent were reduced slightly after passing through the intermittent sand filters.

Chemical Oxygen Demand (COD) and Soluble Chemical Oxygen Demand (SCOD)--

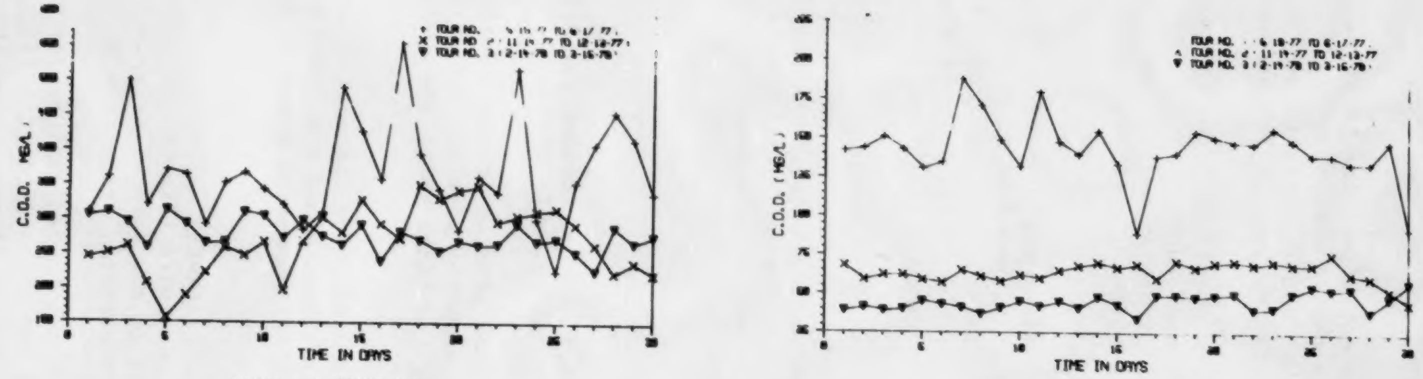
Mean total and soluble chemical oxygen demand concentrations for all sampling points and tours at Moriarty are presented in Table 19.

Both COD and SCOD follow essentially the same general trends. Both parameters will be discussed in one section by sampling points. The variations in total and soluble COD with time during the three tours are shown in Figures 42 and 43, respectively.

Sampling point #1--The first sampling period exhibits the most fluctuation and the tour mean was 369 mg/l (Figure 42). The second and third tour mean values were much more consistent with similar respective means of 269 and 276 mg/l.

The soluble component of total COD was significantly different (5 percent level) between the first and the last two tours (Figures 42 and 43). During tour #3, 45 percent of the total COD was in the form of soluble COD; whereas, tours #2 and #3 were 80 percent and 76 percent, respectively.

Sampling points #2 and #3--The higher influent concentrations for tour #1 are reflected in the lagoon system effluent COD and soluble COD (Figures 42 and 43). During tour #1 the lagoon system removed 61 percent of the total



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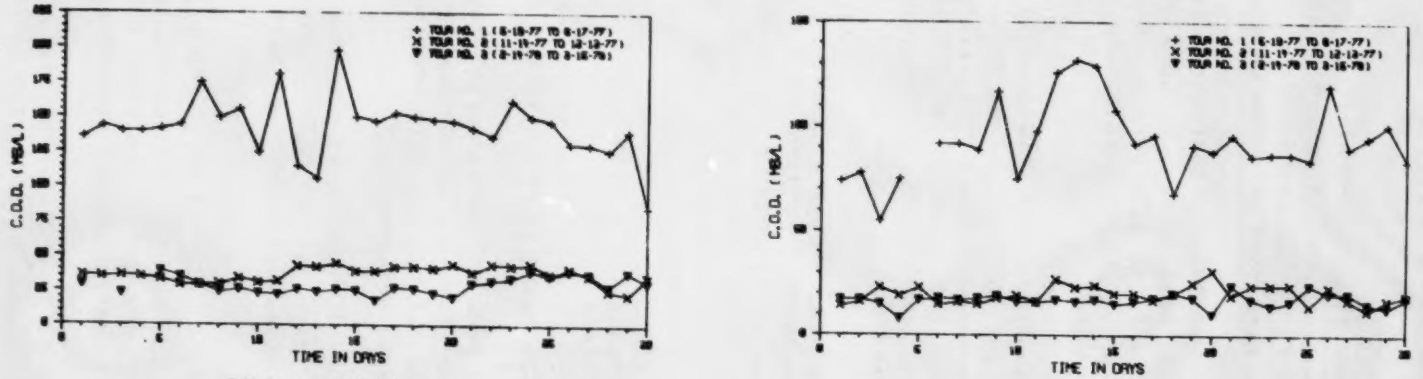

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Figure 42. The relationship observed between chemical oxygen demand and time in days for the three tours at each of the four sampling points used to monitor the Moriarty wastewater treatment facility.

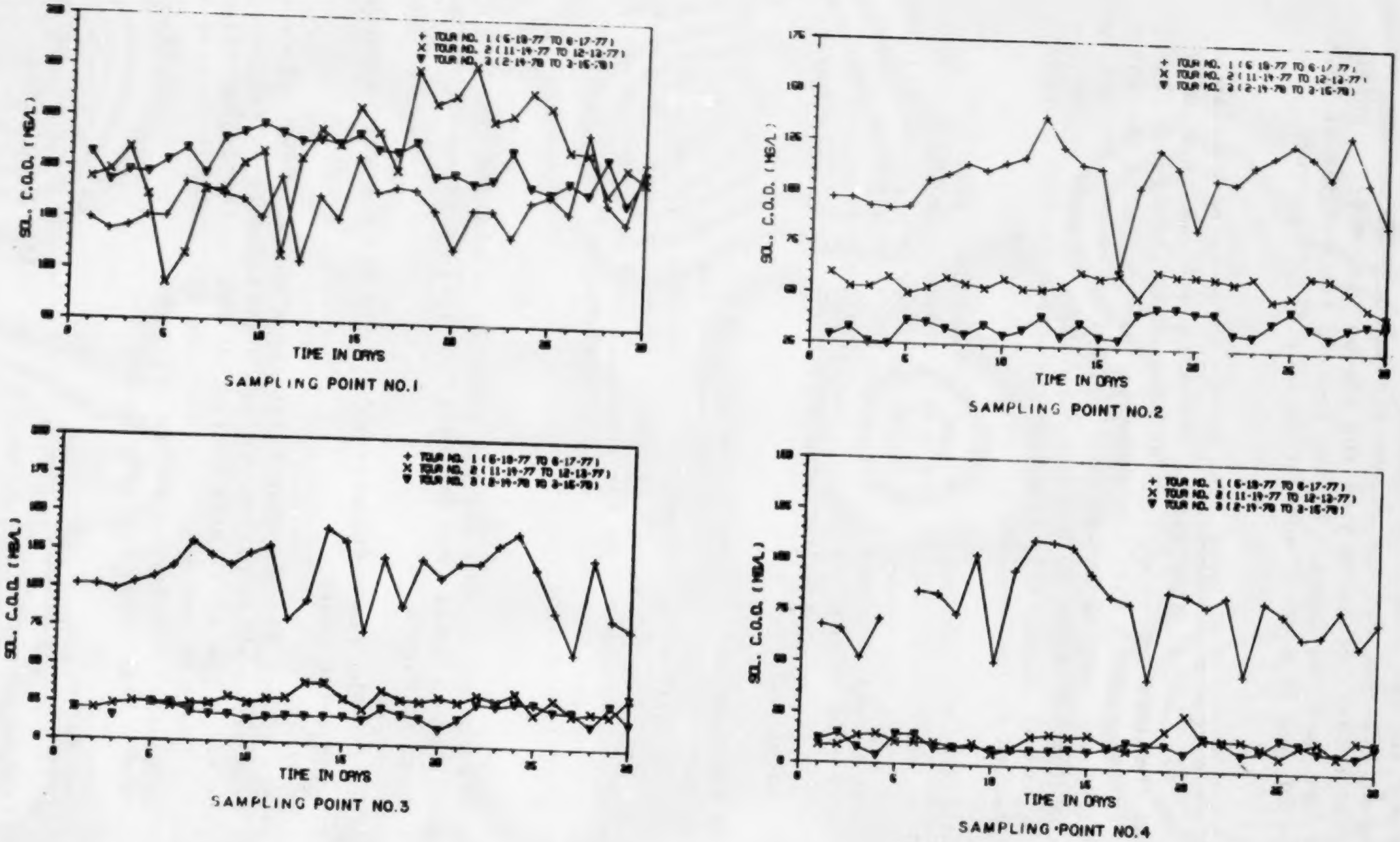


Figure 43. The relationship observed between soluble chemical oxygen demand and time in days for the three tours at each of the four sampling points used to monitor the Moriarty wastewater treatment facility.

COD with a mean concentration of 144 mg/l, and 35 percent of the soluble component was removed and the mean SCOD concentration was 109 mg/l. Chlorination of the lagoon effluent did not change the COD or SCOD concentrations during tour #1. The removal efficiency of the lagoon system was significantly better for the last two tours. During tour #2 the removal of both total and soluble COD was 75 percent and during tour #3, 83 percent of both was removed.

COD and SCOD were reduced considerably in the chlorinated samples during tours #2 and #3. Since chlorination was not practiced constantly during tour #2 and the apparent reduction was consistent throughout the sampling period, it is unlikely that the reduction was caused by the chlorine. The location of the sampler intake near the bottom of the contact basin may be the cause of the variation in the concentrations of SCOD at the two sampling stations, but it is unlikely that the reduction in SCOD without chlorination was caused by the location of the sampler inlet.

Sampling point #4--High concentrations of COD and SCOD observed during tour #1 were not reduced to the low levels observed in the filter effluent during the other two tours. Operational problems with the filters occurred during tour #1 and this may have contributed to the poorer filter performance. Thirty five percent of the COD was removed during tour #1 and the mean filter effluent concentration was 93 mg/l. The SCOD comprised 84 percent of the total COD.

Mean COD and SCOD concentrations in the applied water for tours #2 and #3 were less than tour #1, and the total COD removal was 69 percent and 62 percent, respectively, with mean effluent concentrations of 20 mg/l and 17 mg/l. The SCOD in the effluent was 65 percent of the total COD. The overall increase in removal was attributed to the application of a lower hydraulic loading rate for the second two tours, and the high applied concentrations and troublesome operations during tour #1.

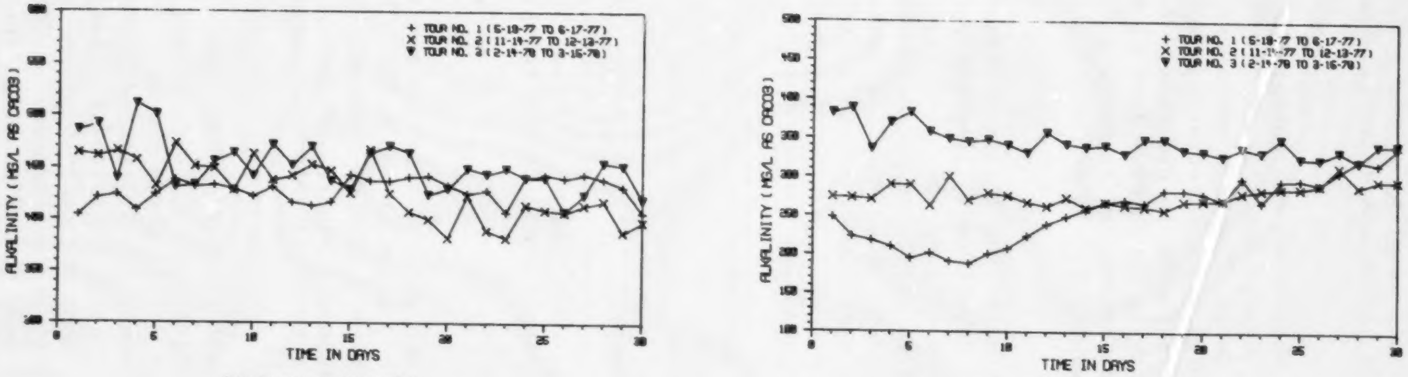
Alkalinity--

Mean alkalinity concentrations for all sampling points and tours at Moriarty are summarized in Table 19. The daily variations in alkalinity concentrations are shown in Figure 44.

Sampling point #1--The raw wastewater alkalinity did not vary significantly throughout the three tours.

Sampling points #2 and #3--The graphs for these two sampling points are essentially the same since chlorination did not significantly affect the alkalinity (Figure 44). The alkalinity concentrations in the lagoon effluent were highest during tours #2 and #3. This increase was probably related to the decrease in algal activity during the colder seasons represented by the last two tours and the high algal activity during the first tour.

Sampling point #4--The small reduction in alkalinity can be attributed to algal activity while the water was on the filter surface raising the pH value to a level adequate to precipitate a portion of the salts in solution.



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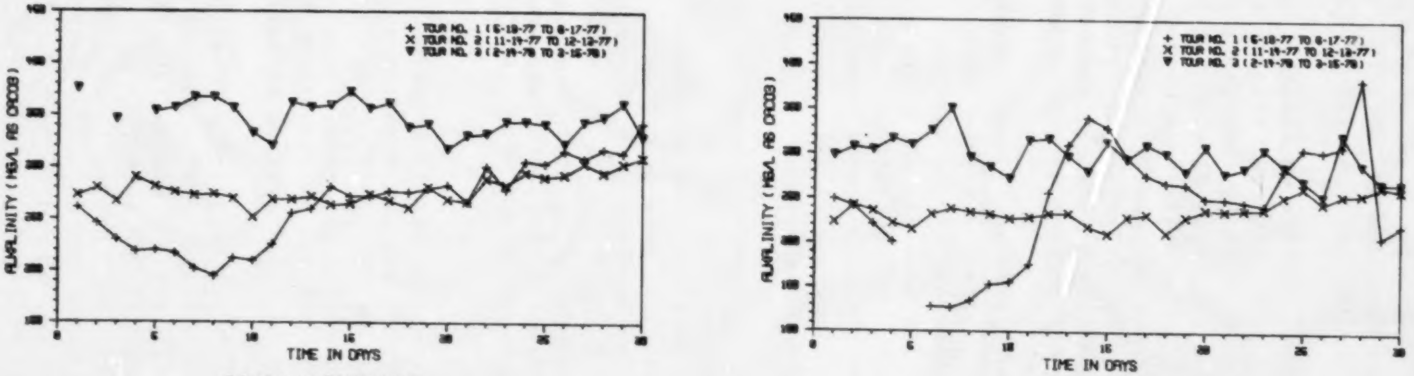

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Figure 44. The relationship observed between alkalinity and time in days for the three tours at each of the four sampling points used to monitor the Moriarty wastewater treatment facility.

Total Phosphorus--

Mean total phosphorus concentrations for all sampling stations and tours at Moriarty are summarized in Table 19. Daily variations in total phosphorus concentrations are presented in Figure 45.

Sampling point #1--The wastewater total phosphorus concentrations increased slightly with each tour (Figure 45). Except for tour #1 the values remained relatively constant throughout each tour. The mean wastewater flow rate was lowest during tour #1 when total phosphorus concentrations were lowest; therefore, the difference cannot be attributed to dilution. Tourist and trucker services are the principal activity in Moriarty. Tour #1 was conducted during the early part of the tourist season and tours #2 and #3 were carried out during slack seasons, and consequently little explanation can be offered for the differences in concentration.

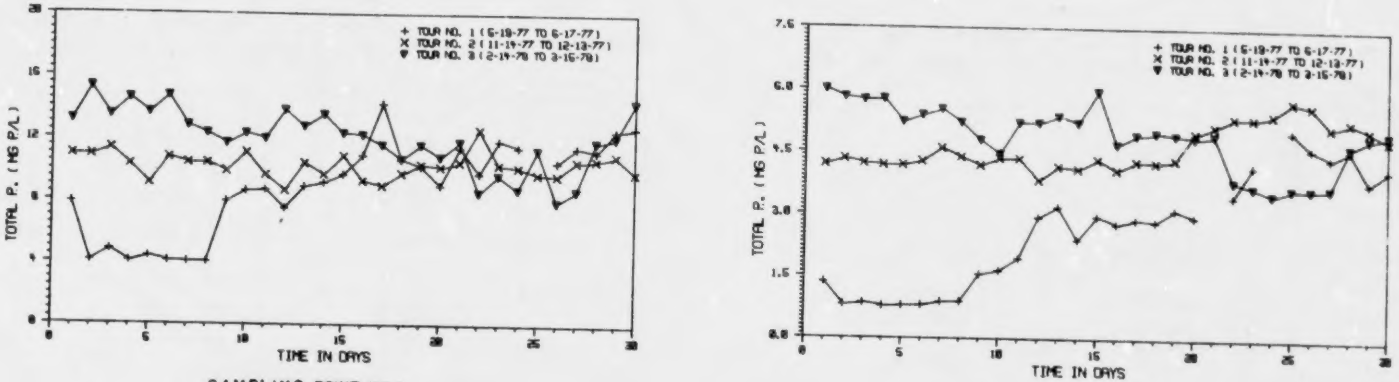
Sampling points #2 and #3--The chlorination of the lagoon effluent did not significantly affect the total phosphorus level; thus, sampling points #2 and #3 were similar and can be discussed as one (Figure 45). The best removal was observed during tour #1, and tours #2 and #3 exhibited the most consistent effluent phosphorus concentrations. The greatest removals during tour #1 can be attributed to the more active algal growth during tour #1 resulting in high pH values in the lagoon effluent aiding in the precipitation of phosphorus compounds and the degradation of phosphorus containing compounds.

Sampling point #4--The removal of total phosphorus by the filters is relative to the condition of the filter media and the concentrations being applied. Total phosphorus concentrations during tour #1 fluctuated as different filter sections were placed in service. Total phosphorus removal during tour #2 was the best with 40 percent removal. This occurred after the major cleaning of the filters. The highest loading of total phosphorus to the filters was observed during tour #3 and the percent removal was low. However, the total reduction in phosphorus was approximately equal to the reduction observed during tours #1 and #2.

Nitrogen Forms--

General--Five nitrogen forms were monitored and the mean concentration over the three tours for the Moriarty system are shown in Table 20. The variations with time for the five parameters plus a plot of inorganic nitrogen (NO_2-N + NO_3-N) for the three tours are shown in Figures 46 through 49 and Figures 51 and 52. A discussion of the major variations is presented by nitrogen form in the following paragraphs.

Total Kjeldahl nitrogen--The total Kjeldahl nitrogen (TKN) concentrations in the raw wastewater were essentially equal during tours #1 and #2. During tour #3 the TKN concentrations were double those measured earlier. The concentrations of TKN were very high and are probably related to the life style of the local population and the discharge of relatively large volumes of restaurant wastes. Raw wastewater mean TKN concentrations for the three tours were 44, 46 and 89 mg N/l. The best percent removal of TKN and the best quality effluent in terms of TKN occurred during tour #2 during cold weather in mid November to mid December.



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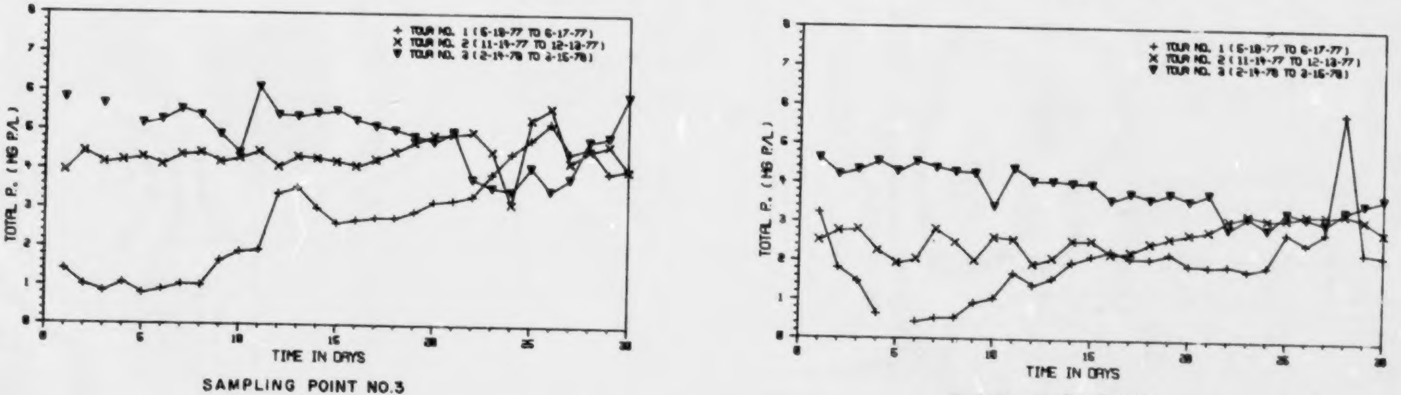

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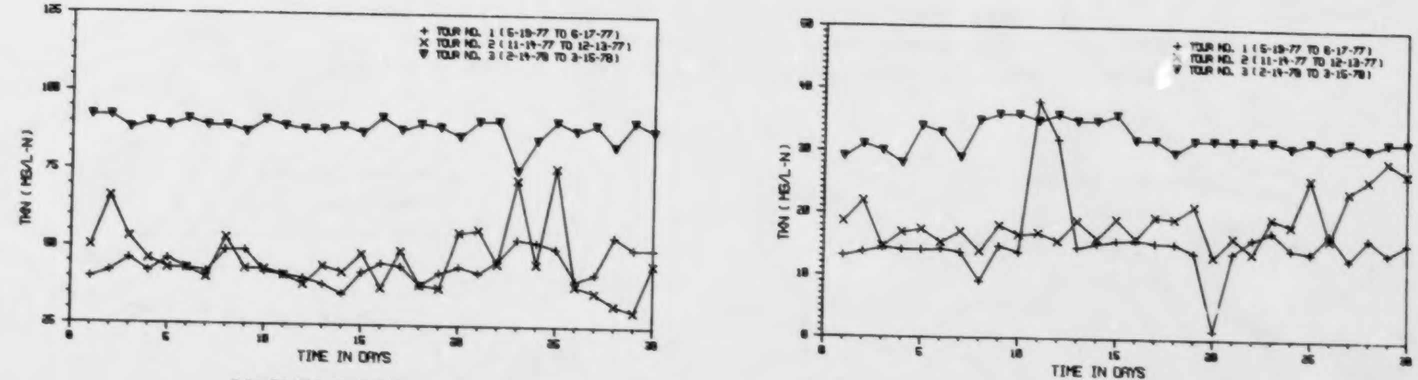
Figure 45. The relationship observed between total phosphorus and time in days for the three tours at each of the four sampling points used to monitor the Moriarty wastewater treatment facility.

TABLE 20. SUMMARY OF MEAN CONCENTRATIONS OF NITROGEN FORMS AT MORIARTY, N.M.

Parameter	Tour #	Lagoon Influent Concentration mg/l	Lagoon Effluent Concentration mg/l	Chlorinated Lagoon Effluent Concentration mg/l	Filter Effluent Concentration mg/l	Overall Removal %
TKN[a]	Tour #1	44	15.5	15.3	9.5	78
	Tour #2	46	18.8	17.2	2.8	94
	Tour #3	89	32	29	24	73
NH_3-N[b]	Tour #1	38	7.02	7.67	5.34	86
	Tour #2	42	15.9	15.5	1.14	97
	Tour #3	34	25	25	21	38
Org-N[c]	Tour #1	9	7.3	7.6	4.4	51
	Tour #2	4	2.9	1.7	1.6	60
	Tour #3	54	7	5	4	93
NO_2-N[d]	Tour #1	0.031	0.252	0.058	1.27	-
	Tour #2	0.101	0.064	0.065	1.58	-
	Tour #3	0.032	0.161	0.164	2.13	-
NO_3-N[e]	Tour #1	0.03	0.02	0.08	0.15	-
	Tour #2	0.07	0.13	0.12	3.2	-
	Tour #3	0.04	0.12	0.13	8.94	-

[a] TKN = total Kjeldahl nitrogen
[b] NH_3-N = ammonia nitrogen
[c] Org-N = organic nitrogen
[d] NO_2-N = nitrite nitrogen
[e] NO_3-N = nitrate nitrogen



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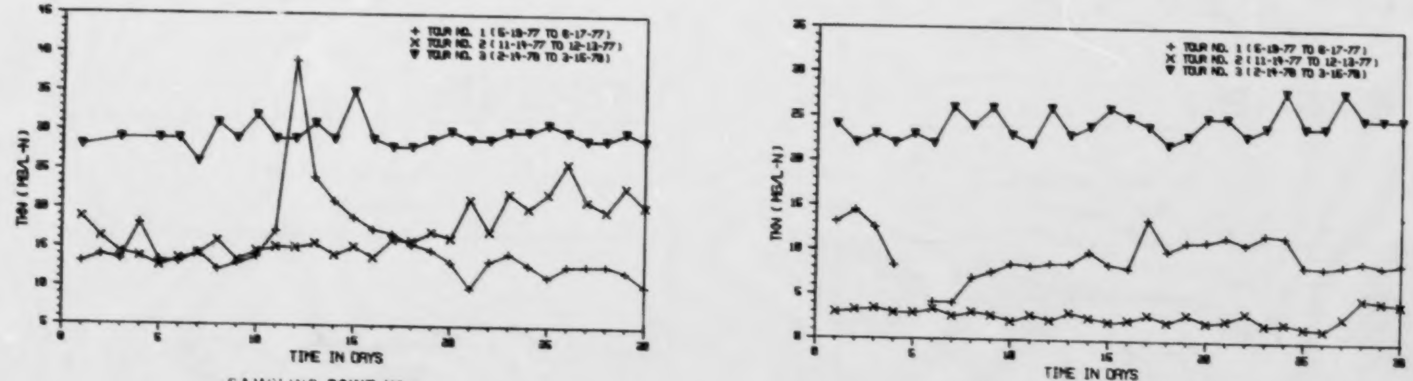

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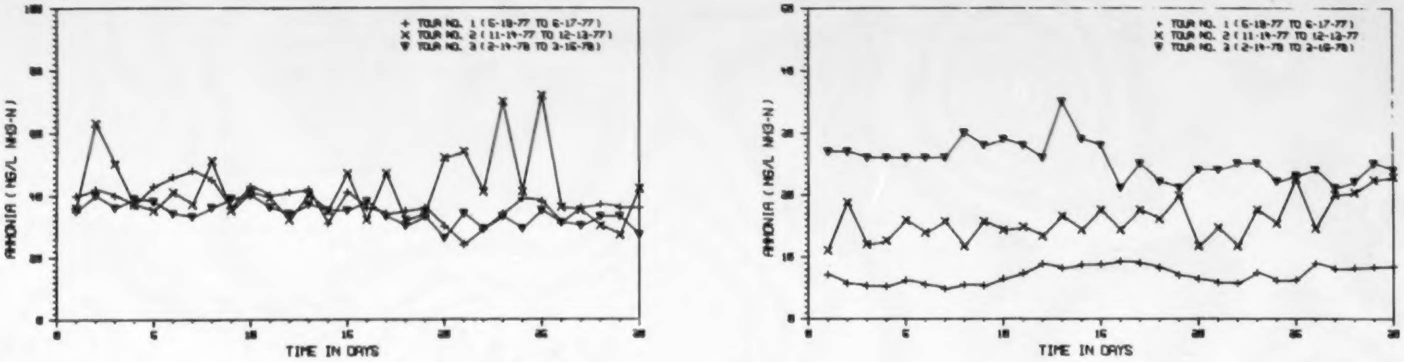
Figure 46. The relationship observed between total kjeldahl nitrogen and time in days for the three tours at each of the four sampling points used to monitor the Moriarty wastewater treatment facility.



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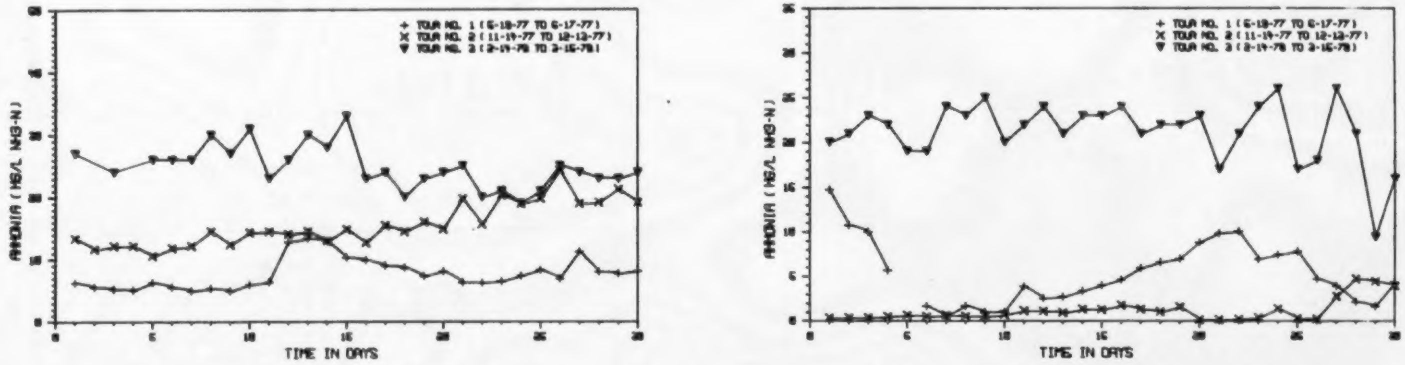

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Figure 47. The relationship observed between ammonia and time in days for the three tours at each of the four sampling points used to monitor the Moriarty wastewater treatment facility.

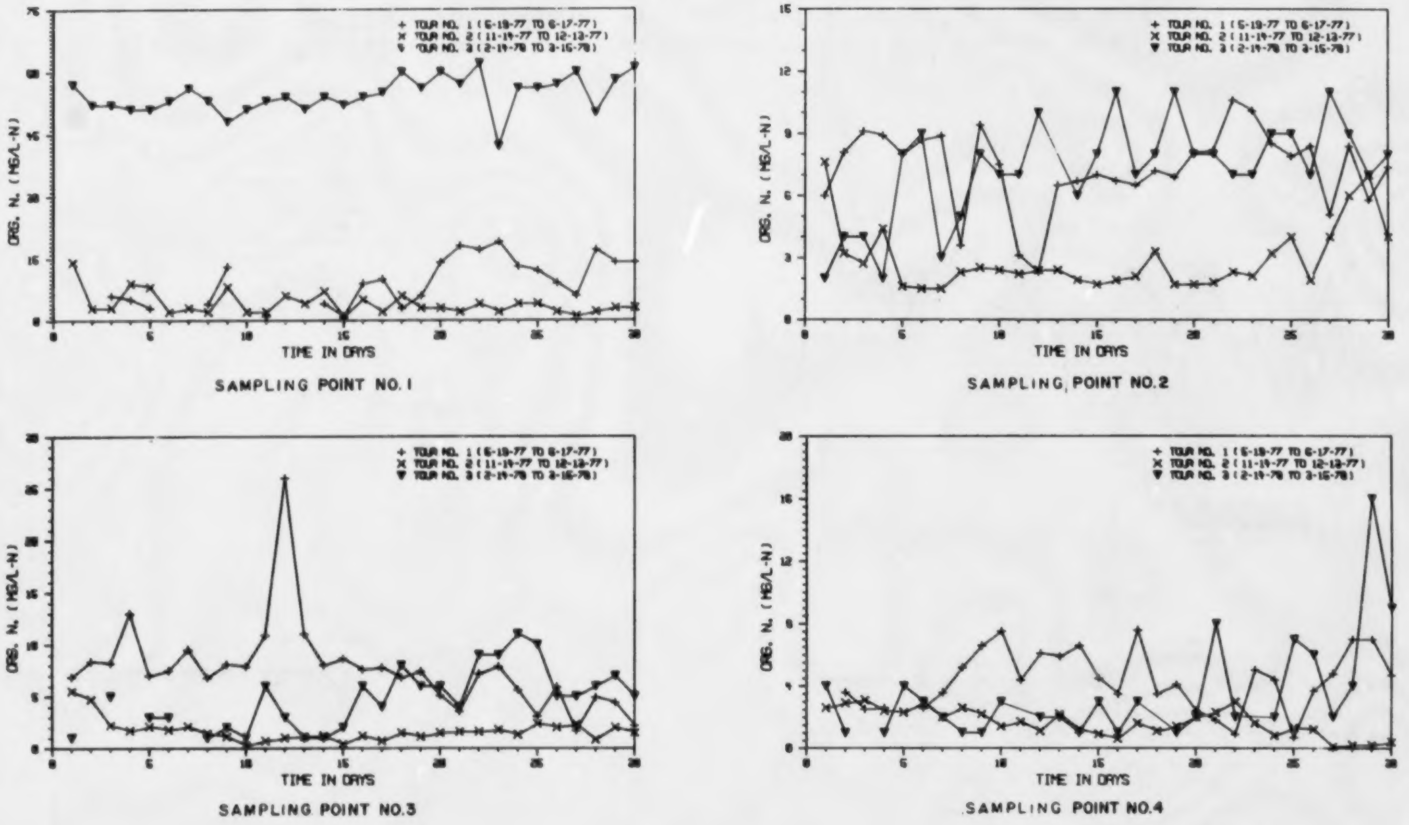

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Figure 48. The relationship observed between organic nitrogen and time in days for the three tours at each of the four sampling points used to monitor the Moriarty wastewater treatment facility.

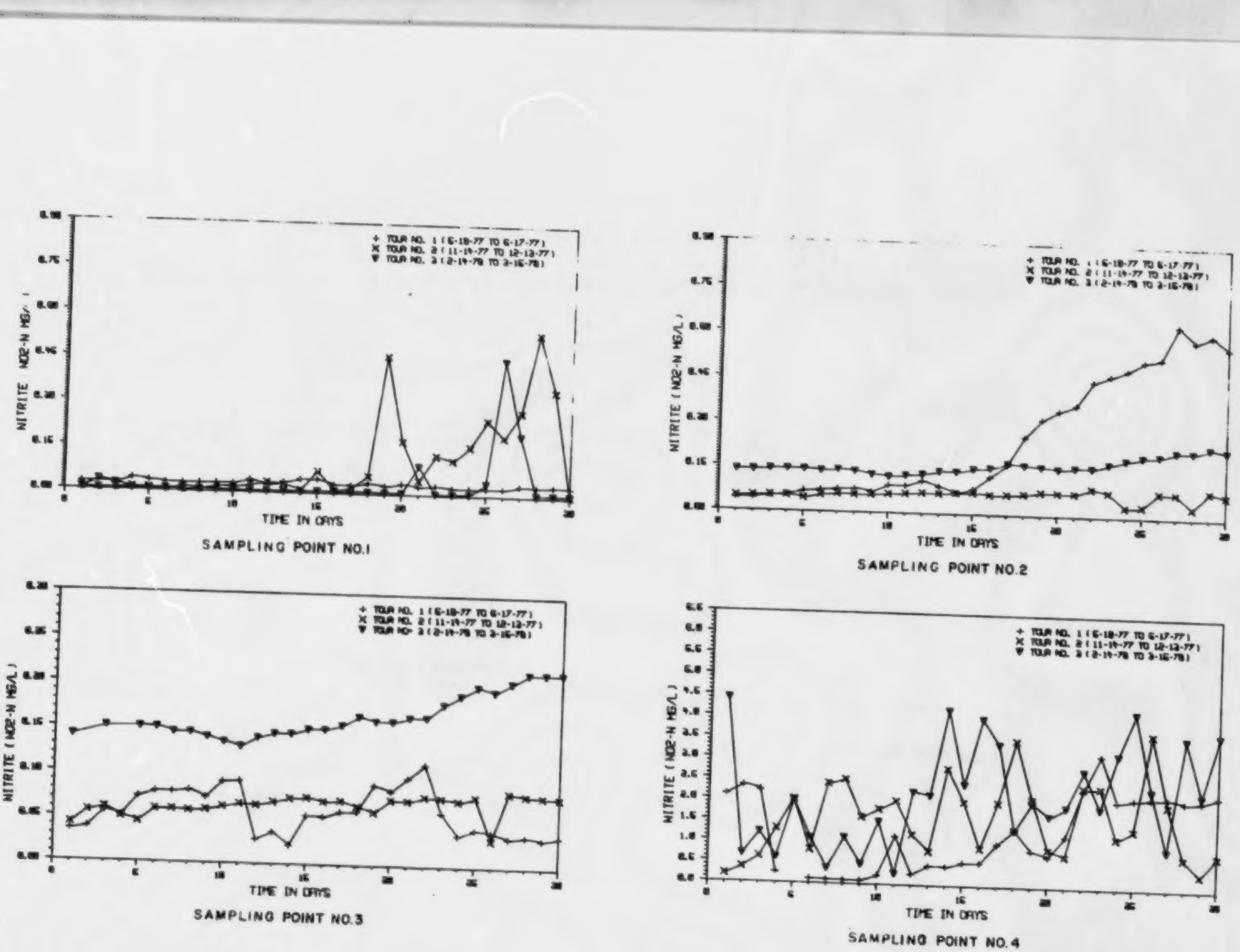

Figure 49. The relationship observed between nitrite and time in days for the three tours at each of the four sampling points used to monitor the Moriarty wastewater treatment facility.

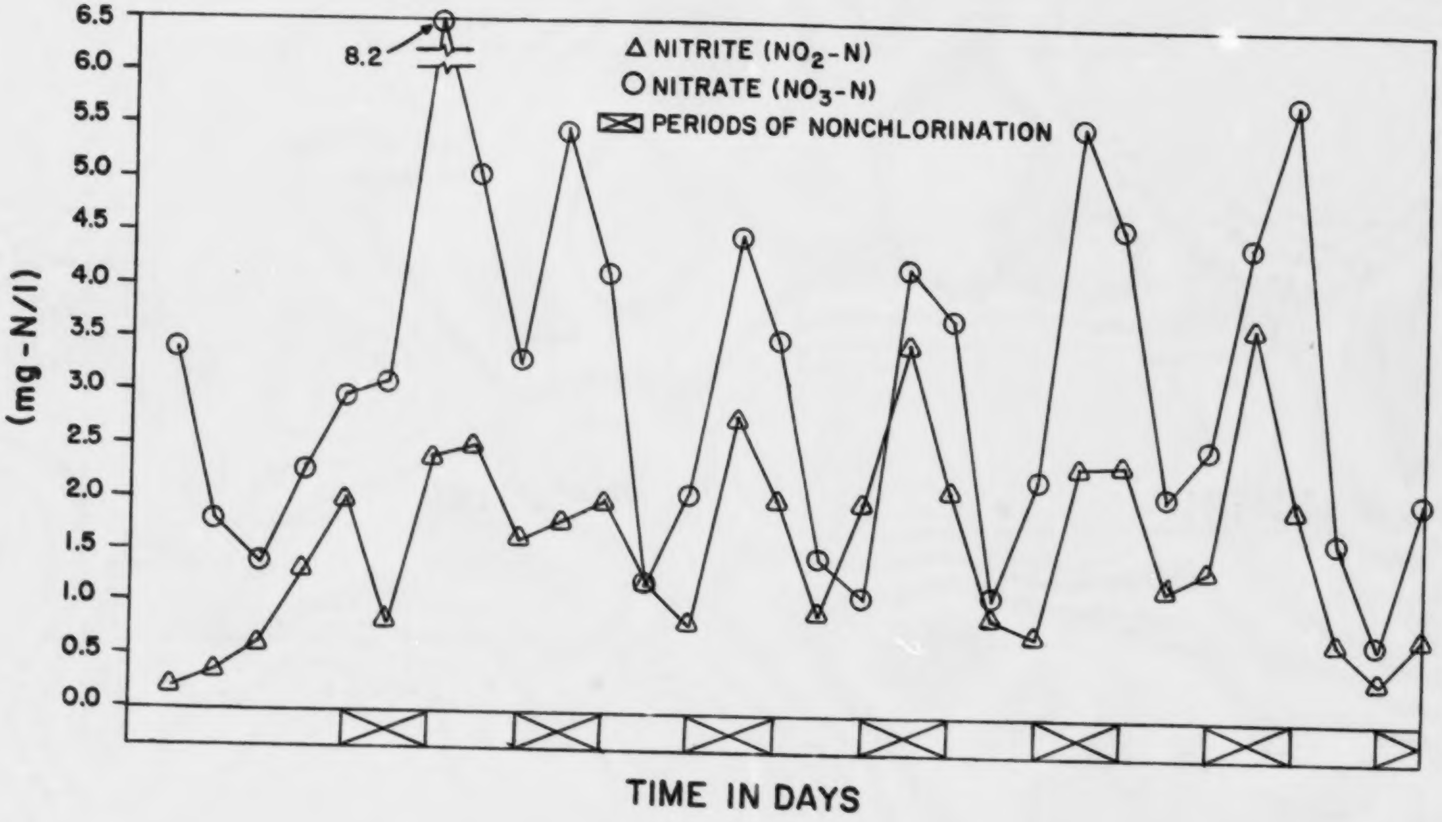

Figure 50. The observed inhibitory affects on the nitrite and nitrate concentrations in the filter effluent during tour #2 at Moriarty, N.M., caused by the chlorination of the wastewater prior to application to the intermittent sand filters.

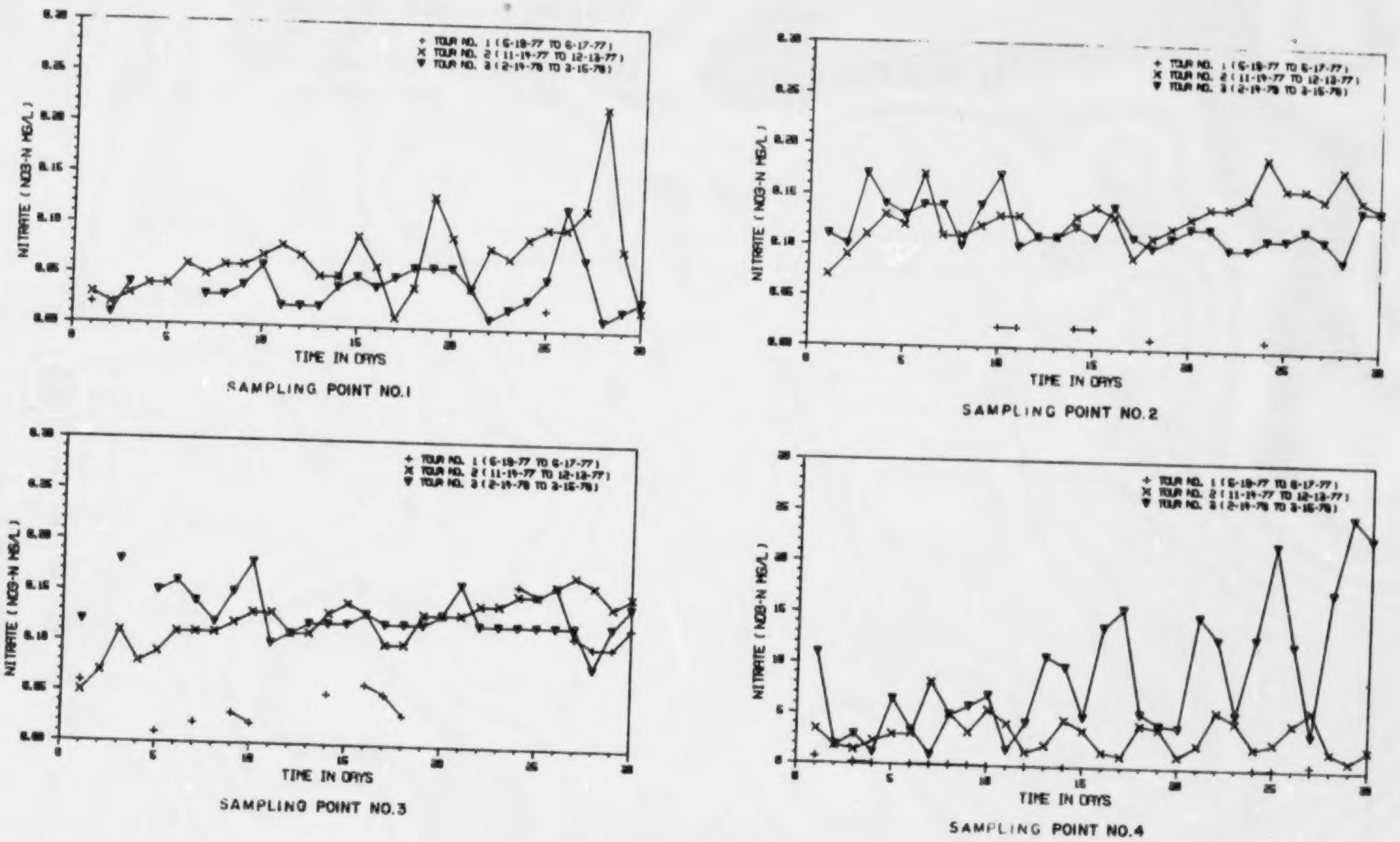

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Figure 51. The relationship observed between nitrate and time in days for the three tours at each of the four sampling points used to monitor the Moriarty wastewater treatment facility.

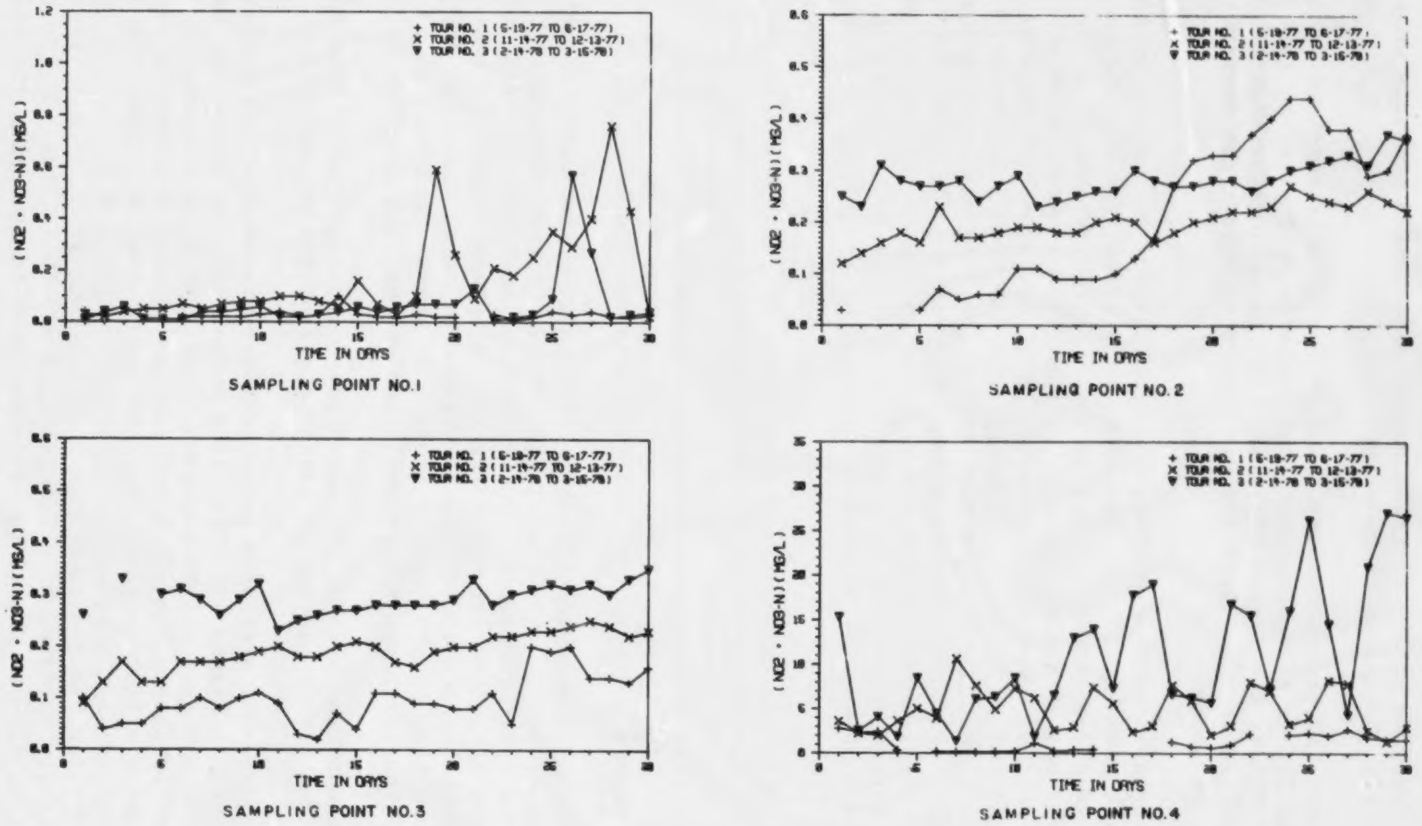


Figure 52. The relationship observed between the combined values of nitrite and nitrate and time in days for the three tours at each of the four sampling points used to monitor the Moriarty wastewater treatment facility.

Chlorination of the lagoon effluent before applying the effluent to the filter reduced the TKN concentrations less than 10 percent. The reduction is a direct function of the chlorine dosage and the low removals only indicate a relatively low dosage of chlorine.

Filter effluent TKN concentrations remained essentially constant during each tour, but the filter effluent concentrations were influenced by the concentrations of TKN in the lagoon effluent. The exceptionally high TKN concentrations applied to the filter did not appear to affect the performance with regard to other parameters.

Ammonia nitrogen--Tour mean ammonia-N concentrations in the raw wastewater were very high with means of 38, 42, and 32 mg N/l, respectively. The consistency of the ammonia-N concentrations in the influent are shown in Figure 47. The wastewater was exceptionally high in ammonia-N concentration when compared with a "typical" domestic wastewater which contains approximately 15-20 mg/l (Metcalf and Eddy, 1972). Although the ammonia-N concentrations were very consistent during a tour, a significant increase was observed as sampling progressed. Influent concentrations were essentially equal during all three tours. The increase in ammonia-N concentration in the lagoon and filter effluents can be attributed to seasonal variations in the large increases in ammonia-N in the raw wastewater during tour #3, and the performance of the system.

Organic nitrogen--The organic-N concentrations in the raw wastewater during tours #1 and #2 were relatively low and the mean values were 9 and 4 mg N/l, respectively (Figure 48). A large increase in organic-N was observed during tour #3 and the mean concentration was 54 mg N/l. The possible explanation for this large increase during tour #3 was that more connections were made and a stronger wastewater reached the system.

The lagoon effluent mean concentration of organic-N fluctuated greatly for each tour (Figure 48). Organic nitrogen removal by the lagoon system was minimal for the first two tours. During tour #3 an 87 percent reduction in organic nitrogen concentration was measured. Although chlorination did not significantly affect the concentrations of organic-N, an extreme high point occurred during the peak of the Daphnia bloom. An unexplained peak also occurred in the filter effluent sample collected on the 29th sampling day.

The intermittent sand filters did not produce any significant reductions in the organic-N content of the lagoon effluent except during tour #1.

Nitrite nitrogen--The nitrite-N concentrations measured at the Moriarty system are presented in Figure 49. Nitrite-N concentrations in the raw wastewater were very low. Only a slight increase in nitrite-N was observed in the lagoon system effluent. The nitrite-N values for each tour were almost constant except for a slight increase near the end of tour #1. The chlorination of the lagoon effluent slightly decreased the nitrite-N mean concentration of 1.66 mg N/l for the filter effluent during tour #2. The nitrification process in the filters appeared to fluctuate on a day-to-day basis. The fluctuations during tour #2 were caused by the experiment to determine the effect of chlorination on filter performance. An examination of the fecal coliform and the nitrite-N plots reveals a relationship between nitrification in the filter and the application of chlorine to the lagoon effluent. The chlorination of the wastewater prior to application to the intermittent sand filters caused an inhibition of the nitrification process as shown in Figure 50.

Nitrate nitrogen--Nitrate-N concentrations in the raw wastewater were low as shown in Figure 51. The lagoon system produced only a small change in the nitrate-N concentrations and little change was caused by the chlorination of the lagoon effluent.

Upon passing the lagoon effluent through the intermittent sand filters, significant nitrification was obtained during tours #2 and #3 with resultant mean concentrations of 3.2 and 8.9 mg N/l. Tour #1 operation did not provide significant nitrification past the nitrite-N stage. Tour #1 was conducted during the early stages of operation and warm weather, and it is possible that the filters had not matured, but it is more likely that the chlorine dose was high enough to inhibit growth in the filter. The inhibition of nitrification by the addition of chlorine to the effluent prior to application on the filters is shown in Figure 50.

Figure 52 shows a plot of inorganic nitrogen (sum of the nitrite-N and nitrate-N) concentrations. The same trends and observations applied to the individual plots are applicable.

Nitrogen mass balance--A mass balance of the nitrogen forms shown in Table 21 indicates nitrogen losses of 76 (tour #1), 84 (tour #2), and 59 (tour #3) percent through the entire Moriarty system. The plant effluents contained high concentrations of nitrogen that were approximately equal to the concentrations in a "normal" domestic raw wastewater (Metcalf and Eddy, 1972). Possible reasons for the high nitrogen concentration were discussed above. More nitrogen removal would be possible if a carbon source were available. In a case such as Moriarty, it is unlikely that additional nitrogen removal is justified, but the possibility for improved removal does exist if conditions change.

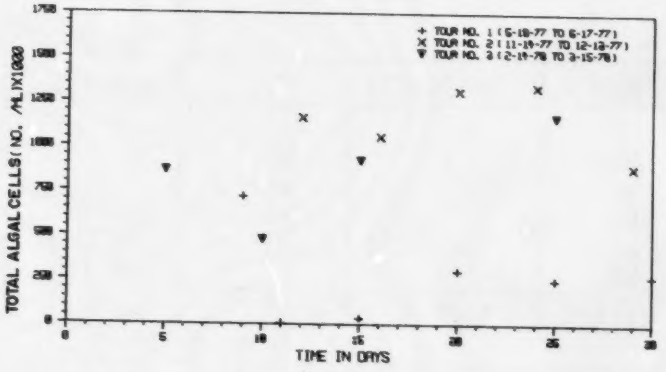
The majority of the nitrogen removal occurred in the lagoon system with 69 (tour #1), 59 (tour #2), and 64 (tour #3) percent reduction. Chlorination practices could be modified to improve nitrogen removal but little removal was observed with the present chlorination practices. The intermittent sand filters removed only 9 (tour #1), 22 (tour #2), and 0 (tour #3) percent of the nitrogen in the chlorinated lagoon effluent. Conversion of ammonia-N to other nitrogen forms is high in an intermittent sand filter, but total nitrogen removal is relatively low because of the aerobic nature of the system.

Algal Concentrations--

The total number of algae cells/ml measured at the three sampling points (#2, #3, #4) are presented in Figure 53. The generic breakdown of the algal counts are presented in Table 22. The predominant genera varied with the time of year but large concentrations of Franceia sp. appeared during all three tours. This genera was found only at Moriarty.

TABLE 21. NITROGEN MASS BALANCE FOR MORIARTY, NEW MEXICO

Tour Number and Sample Location	Mean Values for Three Sampling Periods mg/l					Overall Reduction %
	NH_3-N	Org-N	NO_2-N	NO_3-N	Total-N	
Tour #1 (May 19-June 17)						
Lagoon Influent	38	9	0.031	0.03	47	-
Lagoon Effluent	7.02	7.3	0.252	0.02	14.6	69
Chlorinated Lagoon Effluent	7.67	7.6	0.058	0.08	15.4	67
Filter Effluent	5.34	4.4	1.27	0.15	11.2	76
Tour #2 (Nov. 14-Dec. 13)						
Lagoon Influent	42	4	0.101	0.07	46	-
Lagoon Effluent	15.9	2.9	0.064	0.13	19.0	59
Chlorinated Lagoon Effluent	15.5	1.7	0.065	0.12	17.4	62
Filter Effluent	1.14	1.6	1.58	3.2	7.5	84
Tour #3 (Feb. 14-Mar. 15)						
Lagoon Influent	34	54	0.032	0.04	88	-
Lagoon Effluent	25	7	0.161	0.12	32	64
Chlorinated Lagoon Effluent	25	5	0.164	0.13	30	66
Filter Effluent	21	4	2.13	8.94	36	59



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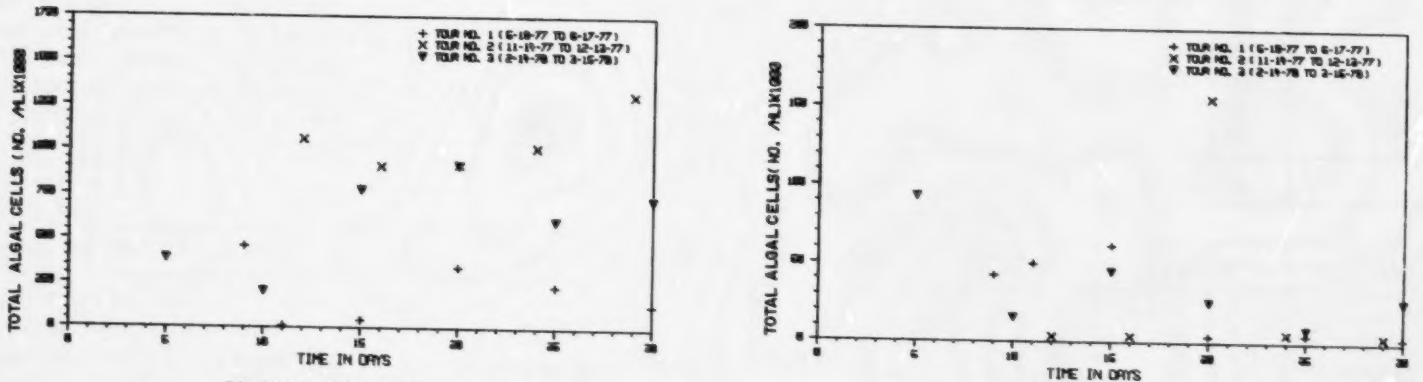

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Figure 53. The relationship observed between total algal cells and time in days for the three tours at each of the three sampling points used to monitor the Moriarty wastewater treatment facility.

TABLE 22. MORIARTY #2 LAGOON EFFLUENT

Tour #1	Sampling Dates					
Algal Genera	5/27/77	5/29/77	6/2/77	6/7/77	6/12/77	6/17/77
Scenedesmus sp., cells/ml	1,922	1,019	9,722	46,136	42,291	215,302
Franceia sp., cells/ml	361,400	1,254	22,266	123,030	30,757	38,447
Cryptomonas sp., cells/ml	-	-	-	99,962	176,855	15,379
Ankistrodesmus sp., cells/ml	961	-	-	-	-	-
Actinastrum sp., cells/ml	353,711	2,666	1,254	30,757	-	3,845
Diatom (*Navicula* sp.), cells/ml	-	78	-	961	-	-
Total Algae, cells/ml	717,994	4,939	33,242	300,846	249,904	272,972
Tour #2	Sampling Dates					
Algal Genera	11/25/77	11/29/77	12/3/77	12/7/77	12/12/77	
Scenedesmus sp., cells/ml	75,264	50,176	106,624	112,896	131,712	
Franceia sp., cells/ml	1,072,512	934,528	1,135,232	1,204,224	721,280	
Cryptomonas sp., cells/ml	6,272	6,272	6,272	12,544	18,816	
Ankistrodesmus sp., cells/ml	6,272	6,272	6,272	6,272	12,544	
Actinastrum sp., cells/ml	-	56,448	56,448	-	-	
Total Algae, cells/ml	1,160,320	1,053,696	1,310,848	1,335,936	884,352	
Tour #3	Sampling Dates					
Algal Genera	2/18/78	2/23/78	2/28/78	3/5/78	3/10/78	3/15/78
Scenedesmus sp., cells/ml	18,816	56,448	43,904	SM	-	SM
Franceia sp., cells/ml	771,456	388,864	840,448	SM	1,128,960	SM
Cryptomonas sp., cells/ml	75,264	28,224	37,632	SM	37,632	SM
Ankistrodesmus sp., cells/ml	-	3,136	-	SM	-	SM
Oscillatoria (filament), cells/ml	-	-	-	SM	-	SM
Total Algal Genera, cells/ml	865,536	476,672	921,984	SM	1,166,592	SM

SM = Sample missing.

TABLE 22. MORIARTY #3 CHLORINATED LAGOON EFFLUENT

Tour #1	Sampling Dates					
Algal Genera	5/27/77	5/29/77	6/2/77	6/7/77	6/12/77	6/17/77
Scenedesmus sp., cells/ml	384	6,272	13,171	119,185	23,068	92,272
Franceia sp., cells/ml	161,477	-	21,638	99,962	61,515	769
Cryptomonas sp., cells/ml	-	-	5,958	84,583	119,185	38,447
Ankistrodesmus sp., cells/ml	384	157	-	-	-	-
Actinastrum sp., cells/ml	296,040	2,352	941	38,447	30,757	384
Diatom (*Navicula* sp.), cells/ml	-	157	157	-	-	38
Total Algae, cells/ml	458,286	9,129	41,866	342,177	234,525	131,911
Tour #2	Sampling Dates					
Algal Genera	11/25/77	11/29/77	12/3/77	12/7/77	12/12/77	
Scenedesmus sp., cells/ml	50,176	31,360	116,032	75,264	87,808	
Franceia sp., cells/ml	997,248	715,008	733,824	909,440	1,160,320	
Cryptomonas sp., cells/ml	-	100,352	31,360	6,272	25,088	
Ankistrodesmus sp., cells/ml	-	25,088	6,272	18,816	-	
Actinastrum sp., cells/ml	12,544	37,632	31,360	6,272	37,632	
Total Algae, cells/ml	1,059,968	909,440	918,848	1,016,064	1,310,848	
Tour #3	Sampling Dates					
Algal Genera	2/18/78	2/23/78	2/28/78	3/5/78	3/10/78	3/15/78
Scenedesmus sp., cells/ml	56,448	17,248	43,904	62,720	3,136	3,136
Franceia sp., cells/ml	332,416	186,592	727,552	846,720	577,024	715,008
Cryptomonas sp., cells/ml	-	-	6,272	-	21,952	6,272
Ankistrodesmus sp., cells/ml	-	-	-	6,272	-	-
Oscillatoria (filament), cells/ml	-	-	-	-	3,136	-
Total Algae, cells/ml	388,864	203,840	777,728	915,712	605,248	724,416

TABLE 22. MORIARTY #4 FILTER EFFLUENT

Tour #1	Sampling Dates					
Algal Genera	5/27/77	5/29/77	6/2/77	6/7/77	6/12/77	6/17/77
Scenedesmus sp., cells/ml	-	-	11,534	-	-	-
Franceia sp., cells/ml	-	-	23,068	-	-	-
Cryptomonas sp., cells/ml	-	-	7,689	3,845	3,845	1,922
Ankistrodesmus sp., cells/ml	-	-	-	-	-	-
Actinastrum sp., cells/ml	42,291	49,981	19,223	38	961	961
Diatom (*Navicula* sp.), cells/ml	-	-	-	-	-	-
Total Algae, cells/ml	42,291	49,981	61,515	3,883	4,806	2,884
Tour #2	Sampling Dates					
Algal Genera	11/25/77	11/29/77	12/3/77	12/7/77	12/12/77	
Scenedesmus sp., cells/ml	314	-	-	157	-	
Franceia sp., cells/ml	2,195	2,038	5,958	3,920	3,136	
Cryptomonas sp., cells/ml	-	-	-	-	-	
Ankistrodesmus sp., cells/ml	-	-	-	-	-	
Actinastrum sp., cells/ml	627	1,568	2,352	1,098	314	
Total Algae, cells/ml	3,136	3,606	8,310	5,174	3,450	
Tour #3	Sampling Dates					
Algal Genera	2/18/78	2/23/78	2/28/78	3/5/78	3/10/78	3/15/78
Scenedesmus sp., cells/ml	1,254	314	-	1,254	-	627
Franceia sp., cells/ml	91,571	14,112	43,904	24,461	8,154	25,402
Cryptomonas sp., cells/ml	-	-	1,254	-	-	-
Ankistrodesmus sp., cells/ml	-	941	-	-	-	-
Oscillatoria (filament), cells/ml	-	-	-	-	-	-
Total Algae, cells/ml	92,826	15,366	45,158	25,715	8,154	26,029

The algae removal by the intermittent sand filters and the chlorination process are shown in Table 23. Removal by chlorination was attributable to the killing of the algae and then sedimentation of the dead cells in the chlorine contact tank. The majority of the algae were removed by the filters.

The first tour removal of only 90 percent was related to the operational problems mentioned earlier.

Flow Rate--

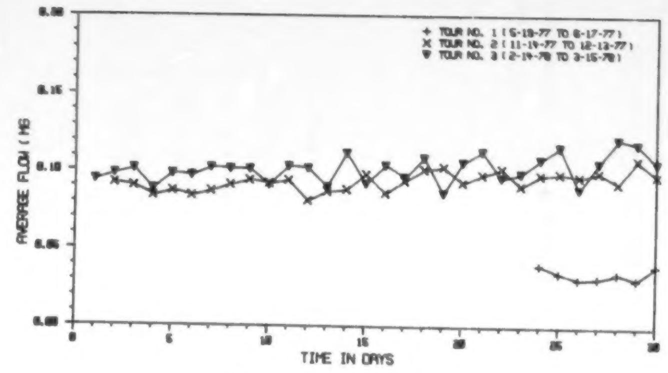
Flow rate was measured at the lagoon influent and at the combination contact/dosing basin. The lagoon influent flow rate was measured continuously for tours #2 and #3, but flow rates were measured only a few days at the end of tour #1 and these data were later found to be inaccurate. The influent flow rate during tours #2 and #3 were very consistent, and the mean values were 348 and 379 m^3/d, respectively. These data are presented in Figure 54.

Flow rate measurements of the lagoon discharge and filter application rates were obtained by two methods at the combination contact/dosing basin. During tour #1 a calibrated bucket was used to obtain a lagoon discharge rate in terms of cubic meters per day. Periodic flow measurements over a 24-hour period were made to identify any daily flow trends, but none were detected. The periodic measurements coupled with a malfunction of the dosing siphon makes these data less desirable than continuous flow monitoring, but this was the best system available without major revisions in the system.

Tours #2 and #3 flow rates were obtained with a stripchart recording of the number of dosing cycles that occurred during a 24-hour day. The proper

TABLE 23. MEAN ALGAL CONCENTRATIONS, CELLS/ml

Sample Location	Tour #1	Tour #2	Tour #3
Lagoon Effluent	263,316	1,149,030	857,696
Chlorinated Lagoon Effluent	202,982	1,043,033	602,634
Filter Effluent	27,560	34,150	34,541
Percent Removal	90	97	96



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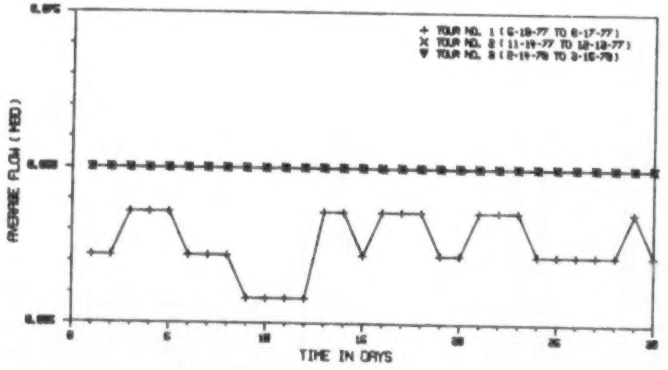


SAMPLING POINT NO.3

Figure 54. The relationship observed between average daily flowrate and time in days for the three tours at each of the two sampling points used to monitor the Moriarty wastewater treatment facility (1 MGD = 3,785 m^3/d).

operation of the dosing siphon with a volume of 95 cubic meters per dose provided accurate flow rate data. During both tours the dosing system averaged two discharges per day and applied 189 m^3/d to the filters.

24-Hour Composite Sample pH and Dissolved Oxygen--

A graphical presentation of the pH values and dissolved oxygen concentrations for each 24-hour composite sample are presented in Figures 55 and 56. These data were collected to verify the absence of unusual data in the in situ sampling program and to establish the general condition of the samples collected. Results were similar to the in situ data.

Ailey Georgia

Sampling Points--

The raw sewage was obtained at the influent lift station wet well prior to being pumped into the aerated lagoon. This was designated sampling point #1 and raw wastewater was sampled at this point during tours #1 and #3. During tour #2 recirculation from the facultative settling pond was mixed with the raw wastewater and pumped into the aerated lagoon. Thus, the raw wastewater influent during tour #2 was diluted by the recirculated effluent (see Figure 4 for the location of the sampling stations).

Effluent from the lagoon system was sampled from the dosing basin prior to application to the intermittent sand filters and this site was identified as sampling point #2. To provide constant monitoring the sample intake was located near the bottom of the dosing basin.

Intermittent sand filter effluent was sampled at the outfall control valve manhole prior to the chlorination system (sampling point #3). The chlorinated filter effluent was obtained at sampling point #4 located at the effluent of the chlorine contact basin between the flow meter weir and the outfall line.

Summary of Results--

A summary of the results for the Ailey wastewater treatment facility is presented in Table 24. Results are presented by tour and sampling point, and the percentage removals obtained with each component of the system are also presented in Table 24. Each of the parameters measured is discussed by sampling point locations in the following sections.

Total Biochemical Oxygen Demand (BOD_5)--

Mean total BOD_5 concentrations for all sampling stations and tours at Ailey are presented in Table 24. The daily variations in the total BOD_5 concentrations are shown in Figure 57.

Sampling Point #1--Although Figure 57 displays a moderate amount of fluctuation, all tour mean BOD_5 concentration were very close. The highest mean concentration of 76 mg/l occurred during the second tour (Table 24). The BOD_5 in the raw wastewater entering the Ailey system was low and apparently there was a considerable amount of infiltration into the sewer system. The influence of infiltration can be found in the wide fluctuations in the flow

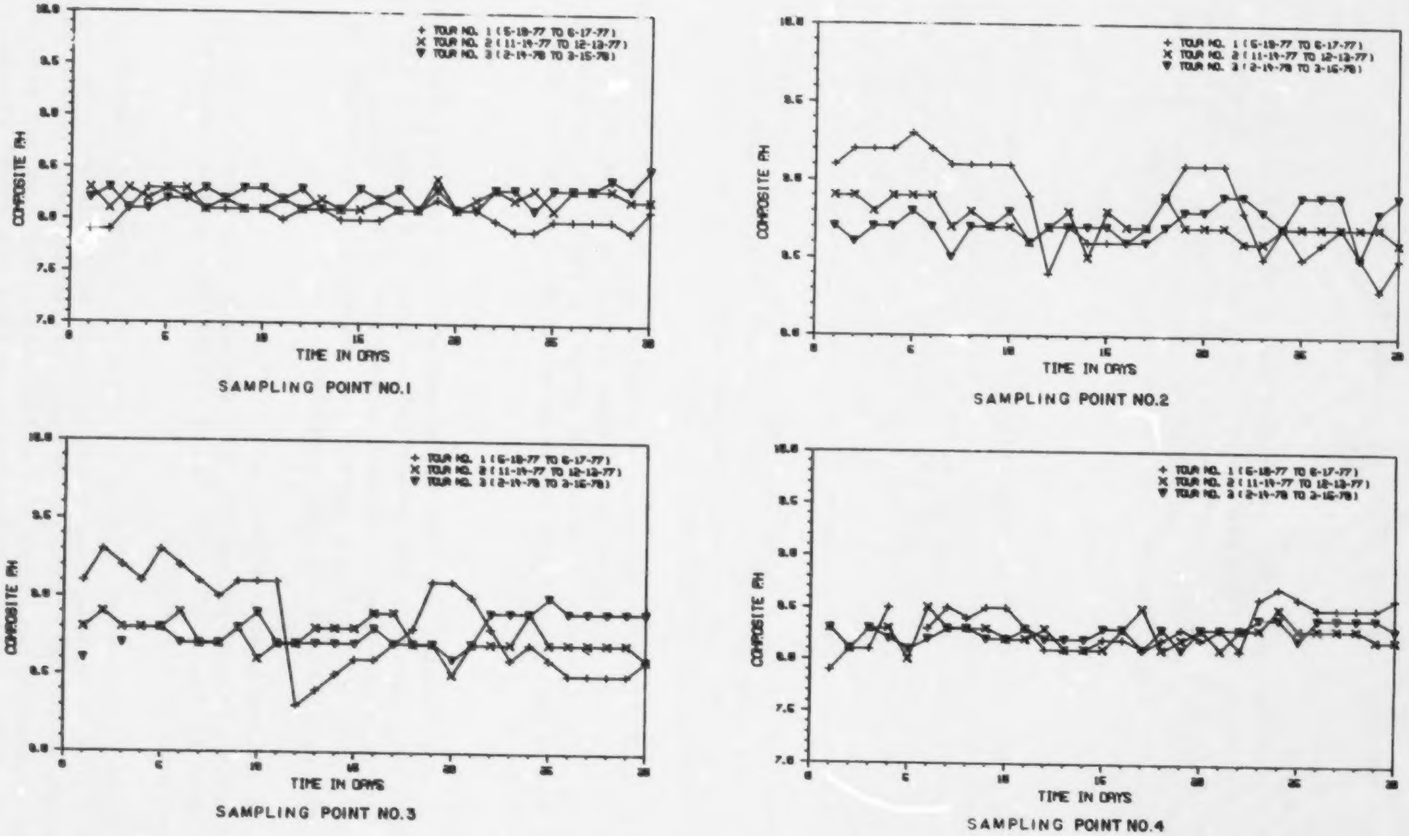


Figure 55. The relationship observed between composite pH and time in days for the three tours at each of the four sampling points used to monitor the Moriarty wastewater treatment facility.

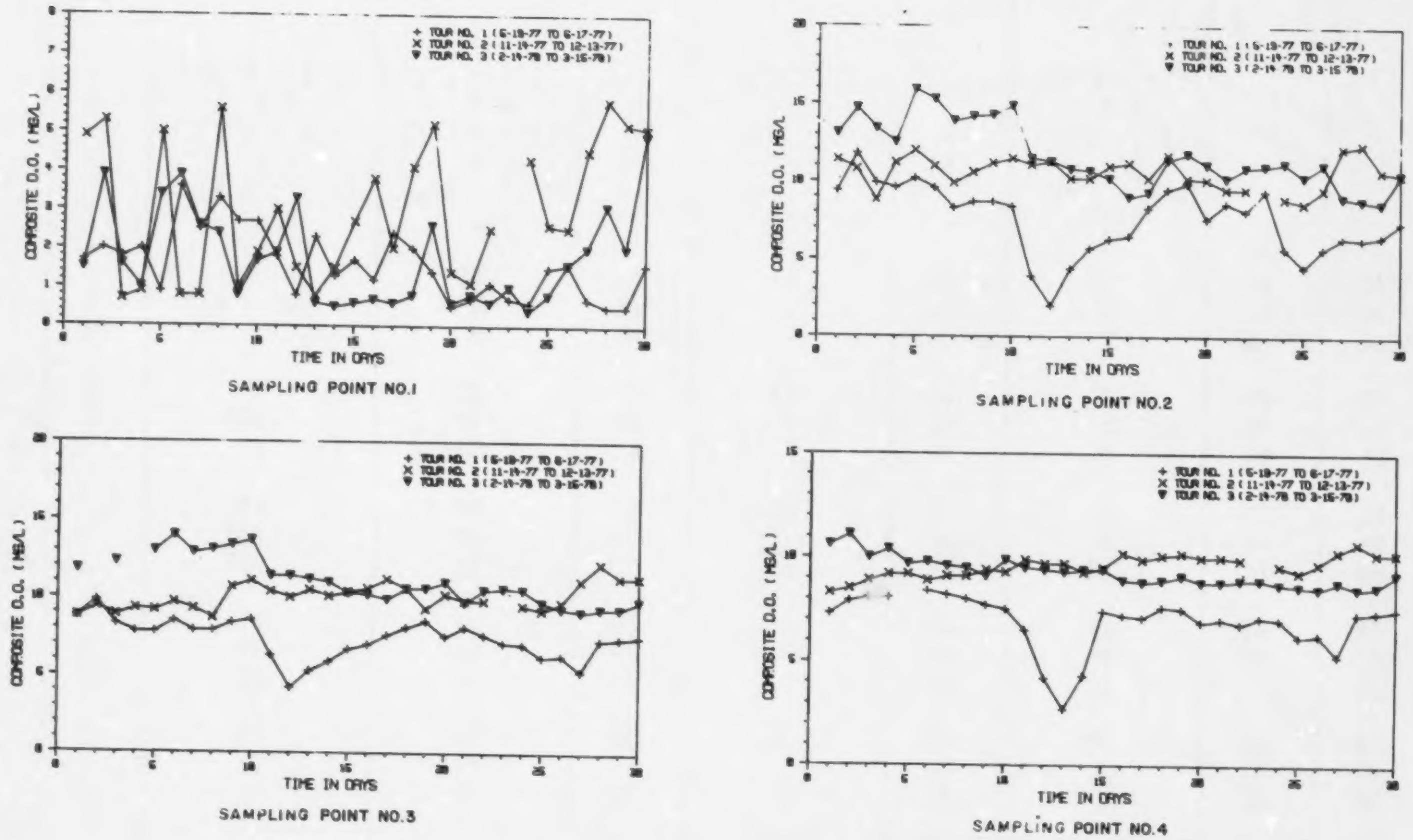


Figure 56. The relationship observed between composite dissolved oxygen and time in days for the three tours at each of the four sampling points used to monitor the Moriarty wastewater treatment facility.

TABLE 24. SUMMARY OF RESULTS OBTAINED AT THE AILEY, GEORGIA, WASTEWATER TREATMENT SYSTEM

Parameter	Tour Number	Lagoon Influent Sampling Point #1	Lagoon Effluent Sampling Point #2		Filter Effluent Sampling Point #3		Chlorinated Filter Effluent Sampling Point #4		Overall Removal
		Concentration mg/ℓ	Concentration mg/ℓ	Removal %	Concentration mg/ℓ	Removal %	Concentration mg/ℓ	Removal %	%
TOTAL BOD_5	1	63	11	83	4	64	3	25	95
	2	76	20	74	5	75	4	20	95
	3	63	34	46	14	59	10	29	84
Soluble BOD_5	1	15	8	47	5	38	5	-	67
	2	19	7	63	5	29	4	20	79
	3	18	14	22	8	43	7	13	61
Suspended Solids	1	116	31	73	14	55	13	7	89
	2	148	48	68	11	77	8	27	95
	3	65	49	25	19	61	17	11	74
Volatile Suspended Solids	1	84	18	79	7	61	6	14	93
	2	125	39	69	6	85	4	33	97
	3	52	39	25	10	74	9	10	83
Fecal[a] Coliform	1	0.58×10^6	8	99.99	3	68.75	1	60.00	99.99
	2	5.19×10^6	9	99.99	1	84.44	<1	28.57	99.99
	3	0.75×10^6	149	99.98	21	85.91	<1	95.23	99.99
pH^b In Situ	1	7.3 (6.9 - 7.6)	8.7 (7.6 - 10.1)	-	6.8 (6.5 - 7.1)	-	6.5 (6.3 - 6.8)	-	-
	2	7.5 (7.3 - 7.8)	9.5 (9.1 - 9.9)	-	7.3 (6.4 - 7.6)	-	7.2 (7.0 -7.4)	-	-
	3	7.0 (6.5 - 7.7)	8.6 (7.7 - 9.3)	-	7.1 (6.6 - 7.7)	-	6.8 (6.5 - 7.2)	-	-

continued

TABLE 24. CONTINUED

Parameter	Tour Number	Lagoon Influent Sampling Point #1	Lagoon Effluent Sampling Point #2		Filter Effluent Sampling Point #3		Chlorinated Filter Effluent Sampling Point #4		Overall Removal
		Concentration mg/ℓ	Concentration mg/ℓ	Removal %	Concentration mg/ℓ	Removal %	Concentration mg/ℓ	Removal %	%
Temperature[c] In Situ	1	16.9	19.9	-	19.2	-	19.7	-	-
	2	25.1	26.1	-	25.6	-	25.5	-	-
	3	12.3	9.5	-	10.8	-	10.5	-	-
Dissolved Oxygen In Situ	1	6.3	8.4	-	7.1	-	6.6	-	-
	2	5.5	9.8	-	5.3	-	7.2	-	-
	3	8.4	12.4	-	9.7	-	9.8	-	-
Total COD	1	111	67	40	28	50	28	-	75
	2	161	57	65	33	42	23	30	86
	3	203	49	76	35	29	24	31	88
Soluble COD	1	26	38	-	21	45	22	-	15
	2	80	43	46	20	53	10	50	88
	3	139	43	69	27	37	16	41	88
Alkalinity	1	62	49	21	42	14	38	10	39
	2	139	105	24	96	9	88	8	37
	3	77	99	-	91	-	81	11	-
Total Phosphorus	1	3.15	1.42	55	1.29	9	1.20	7	62
	2	7.82	3.84	51	3.10	60	2.60	16	67
	3	3.90	4.03	-	3.61	7	3.56	1	9
Flow[d] Rate	1	-	-	-	-	-	0.077	-	-
	2	-	-	-	-	-	0.029	-	-
	3	-	-	-	-	-	0.105	-	-

[a] Expressed in organisms/100 mℓ.

[b] Expressed as geometric mean in pH units (range of values).

[c] Expressed in °C.

[d] Expressed in million gallons/day.

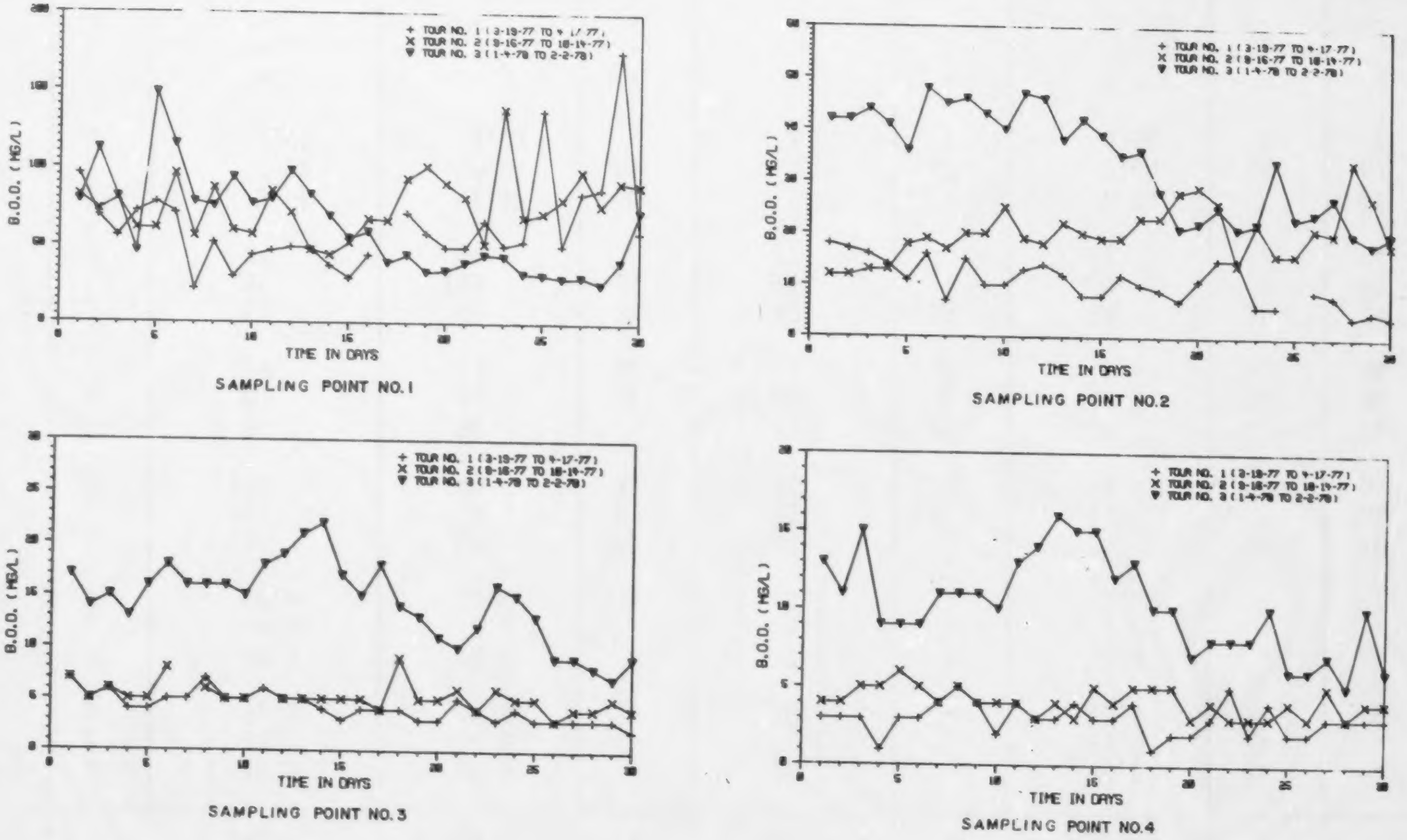


Figure 57. The relationship observed between biochemical oxygen demand and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.

rates entering the plant. Flow rates varied from a low mean of 110 m^3/d during a dry period to a high mean of 564 m^3/d during a wet season, or a five fold increase in flow rate.

Sampling Point #2--The BOD_5 mean concentrations for the three tours progressively increased in the lagoon effluent (Figure 57). The best effluent BOD_5 mean value of 11 mg/l was observed during tour #1. During the second sampling period the mean BOD_5 was 20 mg/l and the mean was 34 mg/l during the third tour. These variations are related to the seasonal changes in the efficiency of the system caused by the major changes in flow rates and rainfall. These changes are shown in Figure 57 where during tour #3 a decrease in flow rate was followed by a decrease in BOD_5 in the lagoon effluent.

Sampling Point #3--During the first two tours mean BOD_5 concentrations of less than or equal to 5 mg/l were observed. Although tour #3 experienced heavy hydraulic loadings plus higher applied BOD_5 concentrations, the filters still performed approximately the same as the first two tours on the basis of percent BOD_5 removed. However, the mean effluent concentration was highest during tour #3 at a concentration of 14 mg/l.

Sampling Point #4--Little reduction in BOD_5 was observed following chlorination of the filter effluent. Percent reductions varied from 20 during tour #2 to 29 during tour #3. This reduction in BOD_5 can be attributed to the oxidation of carbonaceous materials by the chlorination process or settling of solids in the chlorine contact tank.

Total Biochemical Oxygen Demand (BOD_5) with Nitrification Inhibitor--

An evaluation of the amount of BOD_5 attributable to the nitrification stage for each sampling point for each tour is shown in Figure 58. The nitrification inhibitor did produce generally lower BOD_5 values for the lagoon influent and effluent than normal BOD_5 evaluations, but the differences were not statistically significant (1 percent level). Since the BOD_5 concentrations in the filter effluents were generally less than 20 mg/l, no significant differences (1 percent level) were observed at these concentrations when inhibitor was added.

Soluble Biochemical Oxygen Demand (BOD_5)--

Mean soluble BOD_5 concentrations for all four sampling locations and three tours at Ailey are presented in Table 24. Daily variations in soluble BOD_5 concentrations are presented in Figure 59.

Sampling Point #1--The soluble BOD_5 ($SBOD_5$) remained fairly constant in the raw wastewater throughout the three tours with means of 15 (tour #1), 19 (tour #2), and 18 (tour #3) mg/l.

Sampling Point #2--The removal of $SBOD_5$ by the lagoon system during tours #1 and #2 were about equal with respective means of 8 mg/l and 7 mg/l (Table 24). During the last tour when high effluent concentrations of total BOD_5 were observed, the $SBOD_5$ effluent concentration increased to 14 mg/l.

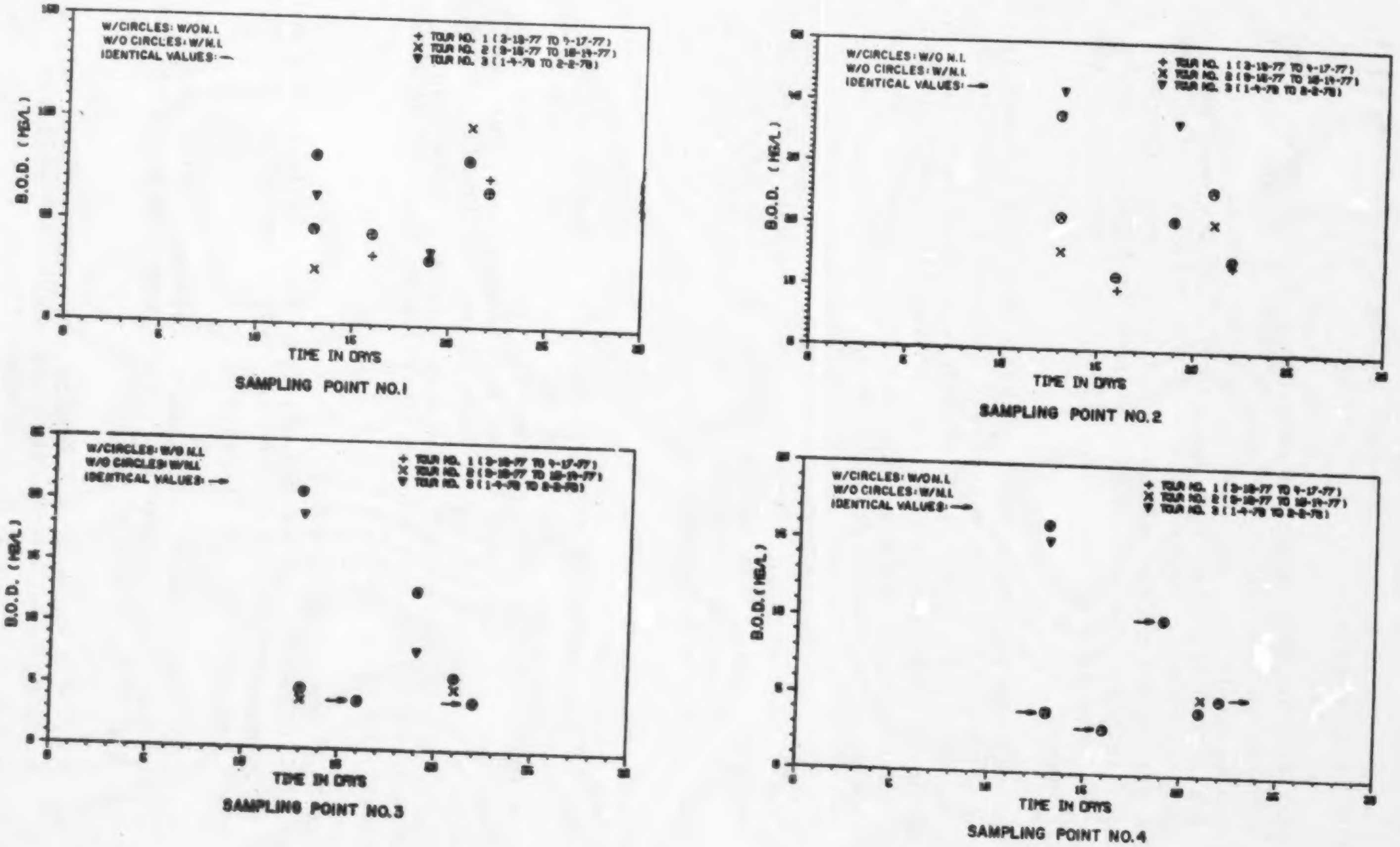


Figure 58. The relationship observed between biochemical oxygen demand and biochemical oxygen demand with nitrification inhibitor for those days during the three tours when simultaneous analysis was performed to monitor the Ailey sewage treatment plant.

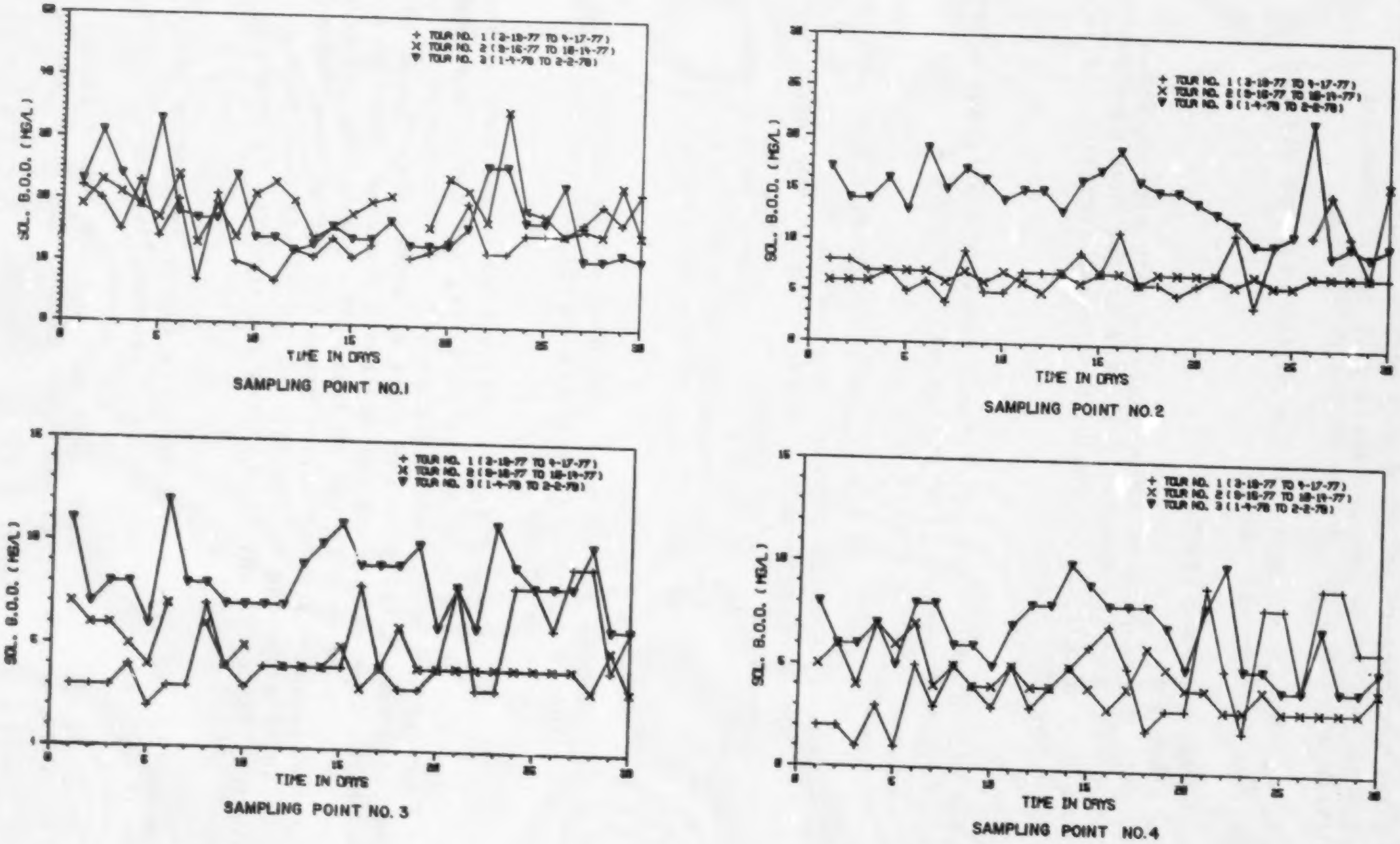


Figure 59. The relationship observed between soluble biochemical oxygen demand and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.

Sampling Point #3--The $SBOD_5$ results for the filter effluent were very erratic with a general tendency to indicate more oxygen demand than the total BOD_5. This tendency is related to the reliability of low biochemical oxygen demand analysis and the algae in the lagoon effluent.

Sampling Point #4--The chlorination of the filter effluent did not produce a significant change in the $SBOD_5$.

Soluble Biochemical Oxygen Demand ($SBOD_5$)
with Nitrification Inhibitor--

Figure 60 presents the results of $SBOD_5$ analyses with nitrification inhibitor (allyl-thiourea) for the samples collected at the four sampling points. The analyses with nitrification inhibitor did not significantly (1 percent level) affect the $SBOD_5$ results.

Suspended Solids--

Mean suspended solids concentrations for all sampling points and tours at Ailey are summarized in Table 24. The variation of suspended solids concentrations with time are shown in Figure 61.

Sampling Point #1--Variations in the influent suspended solids concentrations were the result of seasonal differences principally related to rainfall. During tour #1 the mean influent suspended solids concentration was 116 mg/l which is a lower concentration when compared with a "typical" domestic wastewater (Metcalf and Eddy, 1972) (Figure 61). The mean concentration of 148 mg/l during tour #2 reflects the recirculation of algal laden lagoon effluent. The mean of 65 mg/l for tour #3 illustrates the dilution factor during the rainy season.

Sampling Point #2--The lagoon effluent suspended solids concentration remained fairly consistent during the three tours except for the tour #1 mean which was 31 mg/l (Figure 61 and Table 24).

Sampling Point #3--The filtered lagoon effluent exhibited some extreme fluctuations in suspended solids concentrations during the three tours and the reasons for the fluctuations are unknown (Figure 61). A four-day cycle can be observed to take place specifically during tours #1 and #3 when the solids would be low for three days and then a one day sharp increase. Sometimes the concentration would increase by a factor of four. The same cycle can be seen in the chlorinated effluent suspended solids graph but not at sampling points #1 or #2. The volatile suspended solids for the filter effluent does not demonstrate this four-day cycle which indicates the increase is from an inorganic source.

The tour means for the filter effluent were fairly consistent with the tour #3 mean of 19 mg/l being the highest, due to high flow rates (Table 24).

Sampling Point #4--The small reductions in suspended solids in the chlorinated effluents was probably attributable to settling of solids in the chlorine contact basin.

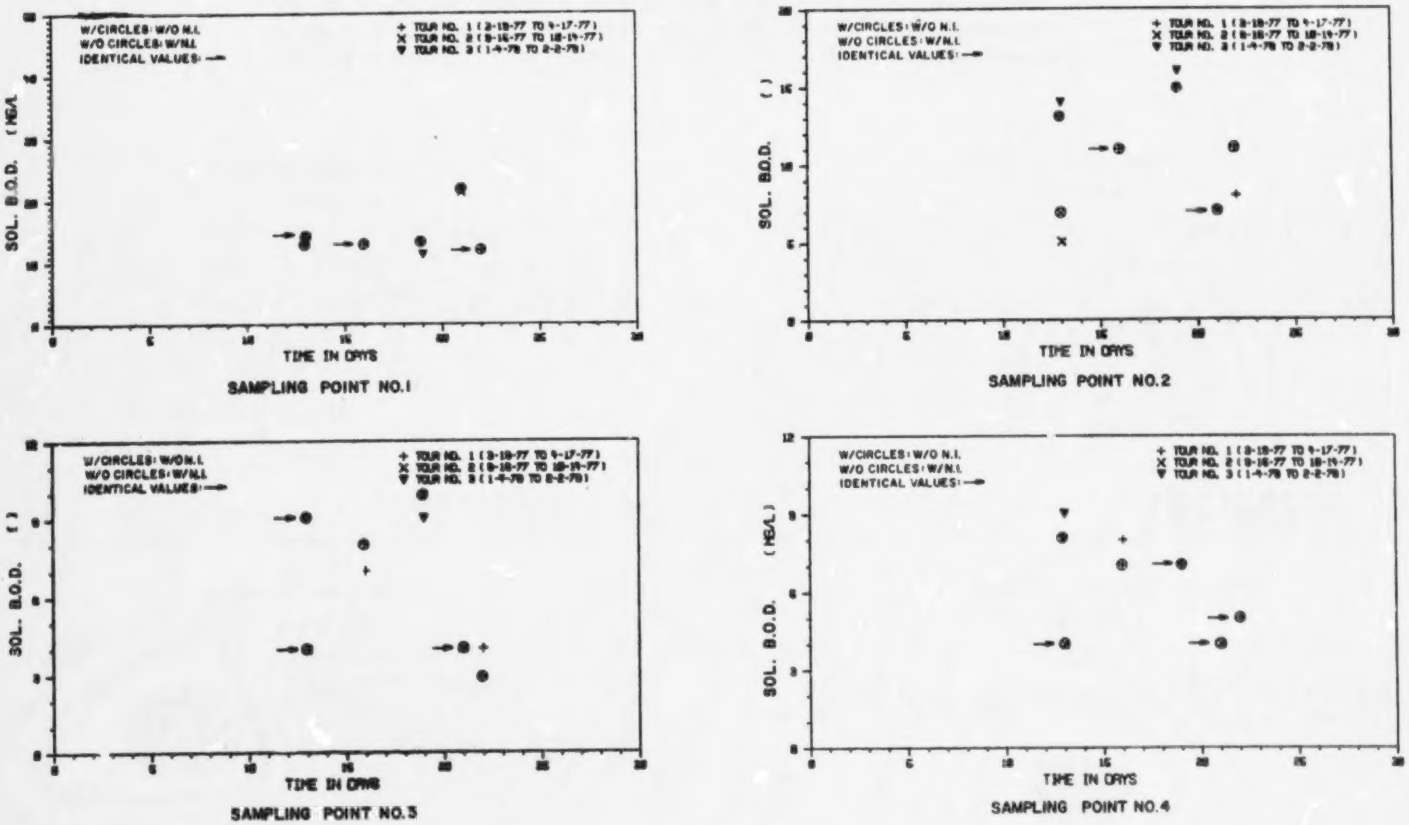


Figure 60. The relationship observed between soluble biochemical oxygen demand and soluble biochemical oxygen demand with nitrification inhibitor for those days during the three tours when simultaneous analysis was performed to monitor the Ailey sewage treatment plant.

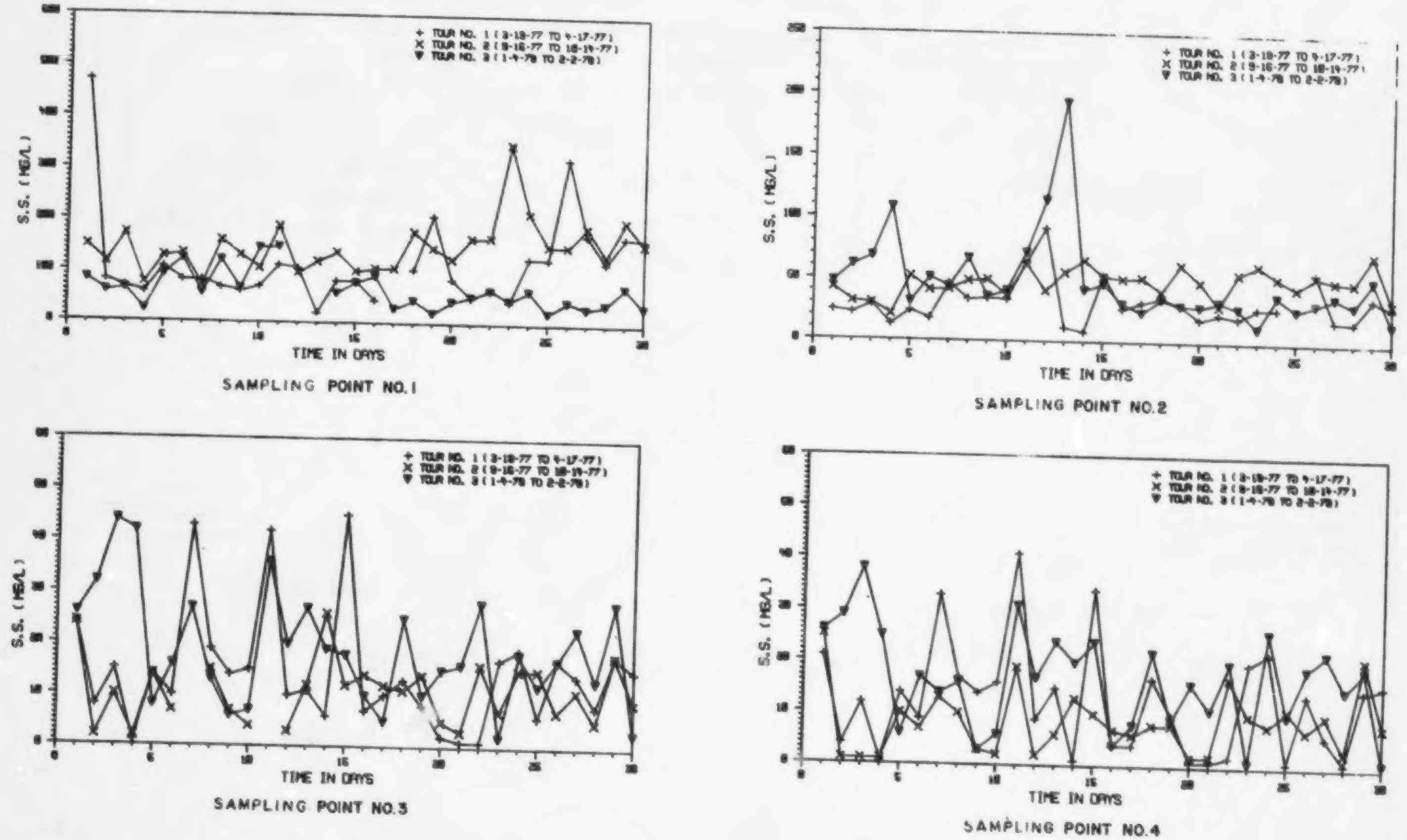


Figure 61. The relationship observed between suspended solids and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.

Volatile Suspended Solids--

The mean volatile suspended solids concentrations for all sampling points and tours at Ailey are presented in Table 24. Daily variations in the volatile suspended solids concentrations are shown in Figure 62.

Sampling Point #1--Variations in the volatile suspended solids concentrations were essentially identical to the variations in the suspended solids concentrations at sampling point #1 (Figure 62). The percentage of volatile matter in the suspended solids was constant; therefore, the similar trends were expected.

The mean volatile suspended solids concentrations fluctuated between each tour and the following tour means were observed: tour #1 - 84 mg/l, tour #2 - 125 mg/l and tour #3 - 52 mg/l.

Sampling Point #2--During tours #2 and #3 the mean volatile suspended solids concentrations were 39 mg/l, and during tour #1 the mean was 18 mg/l (Table 24). Removal of volatile suspended solids by the lagoons exceeded 69 percent except during tour #3 when the removal was 25 percent. The small reduction was primarily due to the low concentration of volatile suspended solids in the raw wastewater caused by the large rainfalls that occurred during tour #3.

Sampling Point #3--The volatile suspended solids concentrations exhibited moderate to high fluctuations in the filter effluent; however, the mean concentrations were only 7 (tour #1), 6 (tour #2), and 10 (tour #3).

Sampling Point #4--The reduction in volatile suspended solids in the chlorination process is probably attributable to settling of solids in the contact tank.

Fecal Coliform--

Geometric mean fecal coliform concentrations for all sampling points and tours at Ailey are summarized in Table 24. The daily variations are presented in Figure 63.

Sampling Point #1--Fecal coliform populations in the lagoon effluent were consistent during sampling periods #1 and #3 with geometric means of 585,000 and 748,000 organisms/100 ml, respectively (Figure 63). During the second sampling period much larger influent fecal coliform concentrations were observed, and it is thought that this increase was due to the warm temperatures of that season. A geometric mean of 5,188,000 organisms/100 ml was calculated for the second tour.

Sampling Point #2--Fecal coliform populations in the lagoon effluent were consistently low during the first two sampling periods with means of 8 and 9 organisms/100 ml (Table 24). With the increased flow rates during tour #3 the detention time was reduced and a significant increase in effluent fecal coliform occurred with a mean of 149 organisms/100 ml. Even with the increase during tour #3, the lagoon system provided an excellent reduction in the fecal coliform bacteria.

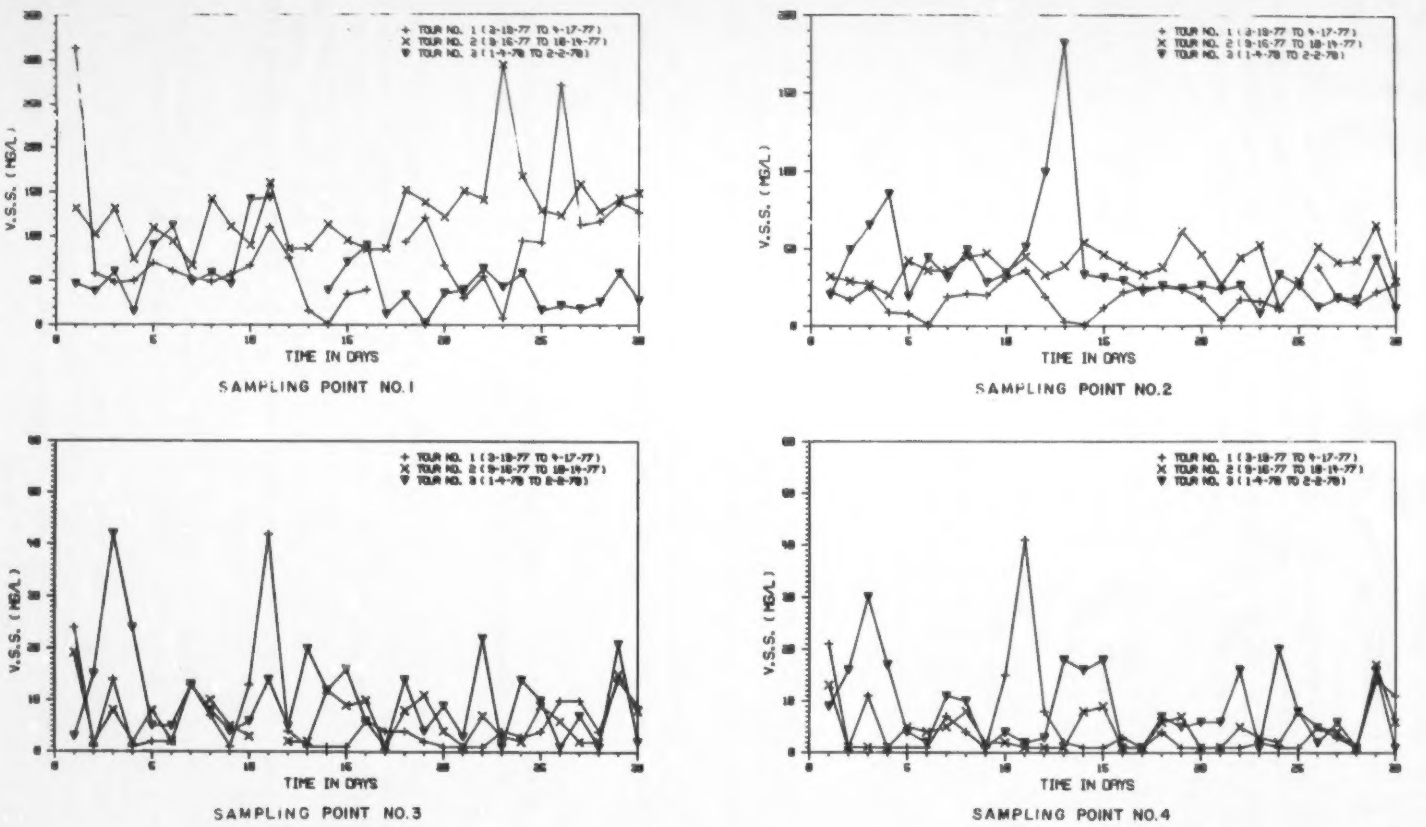


Figure 62. The relationship observed between volatile suspended solids and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.

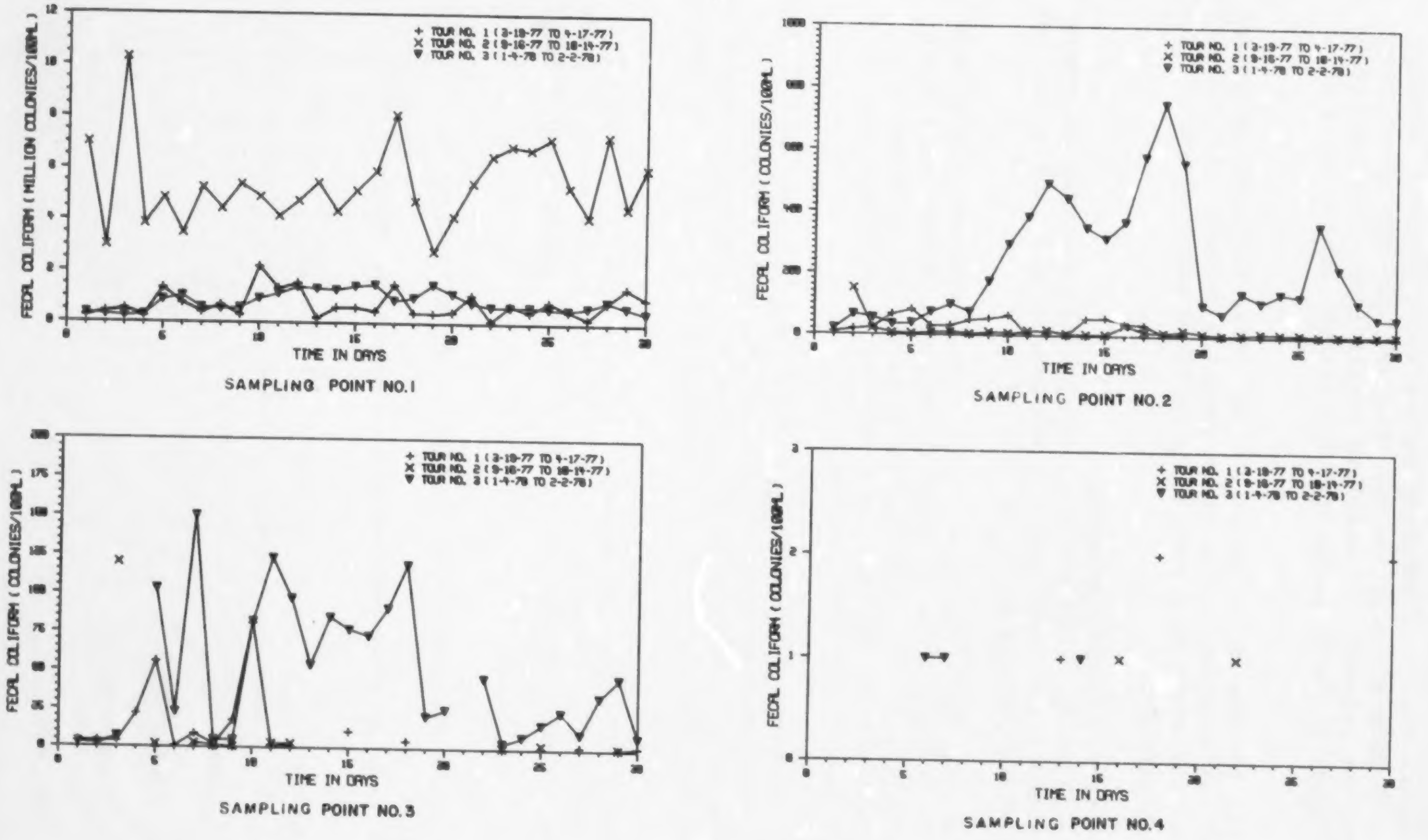


Figure 63. The relationship observed between fecal coliform bacteria and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.

Sampling Point #3--Intermittent sand filtration reduced the fecal coliform counts during the first sampling period by 75 percent. During the second tour a 78 percent reduction was obtained, and the third tour produced an 89 percent reduction in coliform populations. The low counts in the filter influent probably influenced the removal during tours #1 and #2.

Sampling Point #4--The chlorination of the filter effluent controlled most of the fecal coliform during the three sampling periods. Of the ninety sampling days, on only seven days were fecal coliform detected and the maximum count was 2 organisms/100 ml.

In Situ pH, Temperature, Dissolved Oxygen--

Mean in situ pH values, temperatures, and dissolved oxygen concentrations for all sampling points and tours at Ailey are presented in Table 24. Daily fluctuations are shown in Figures 64, 65, and 66.

In situ pH at the four sampling stations were consistent during each tour (Figure 64). Variations in pH value during each of the tours appear to be seasonally oriented. The most variation in the pH value was observed on the first tour at sampling point #2 (lagoon effluent) when an apparent seasonal lagoon overturn occurred.

The in situ temperature graphs for the four sampling locations follow the same general trend and are nearly identical as shown in Figure 65. This general trend held for the relative consistency in all three tours, and the mean temperatures were: tour #1 - 18.9 C, tour #2 - 25.6 C and tour #3 - 10.8 C.

In situ dissolved oxygen also appeared to vary with the season of the year as illustrated by the differences between the tour means at each sampling location in Table 25 and Figure 66. The raw influent was a fresh

TABLE 25. IN SITU DISSOLVED OXYGEN CONCENTRATION, mg/l

Sampling	Tour #1	Tour #2	Tour #3
Lagoon Influent	6.3	5.5	8.4
Lagoon Effluent	8.4	9.8	12.4
Filter Effluent	7.1	5.3	9.7
Chlorinated Lagoon Effluent	6.6	7.2	9.8

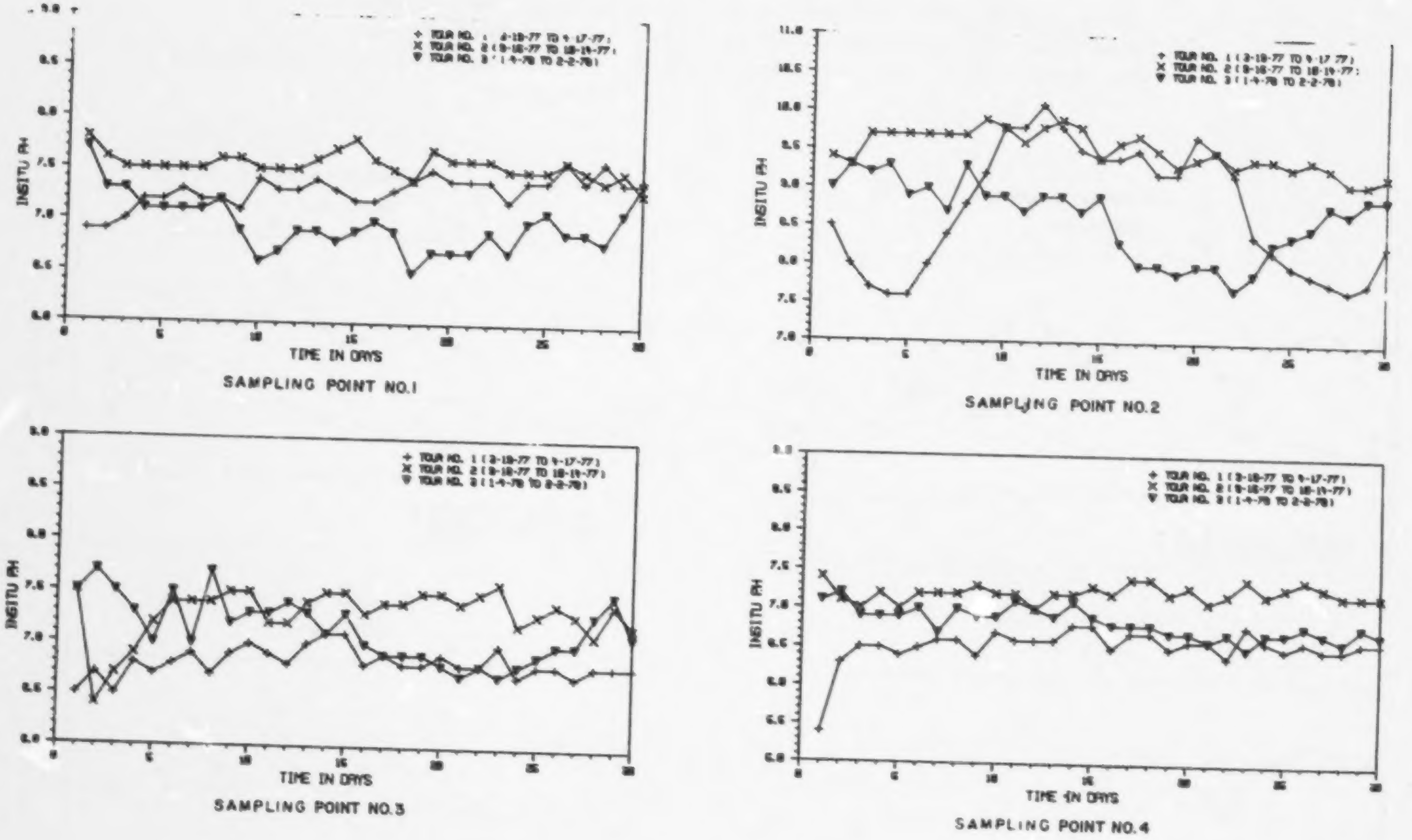


Figure 64. The relationship observed between in situ pH and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.

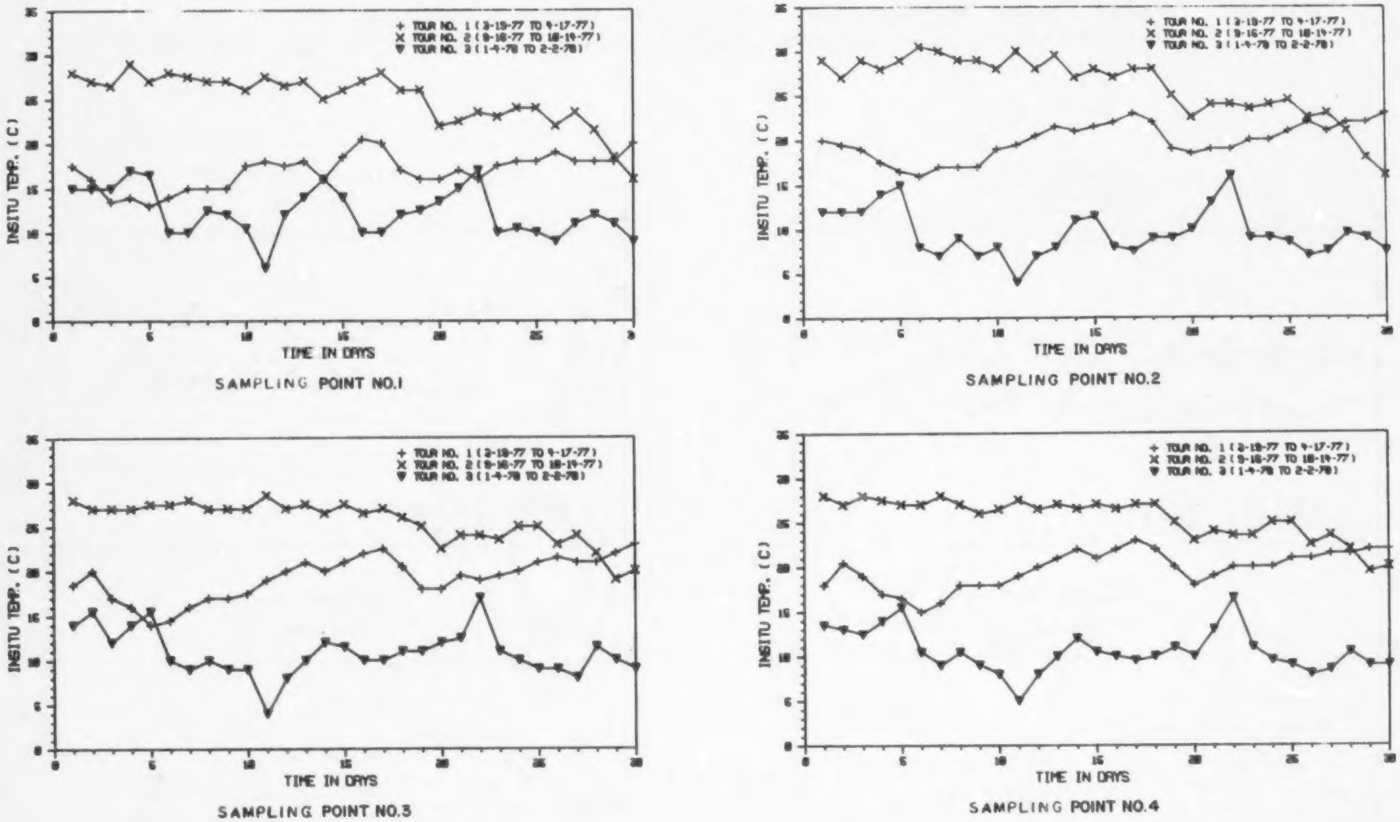


Figure 65. The relationship observed between in situ temperature and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.

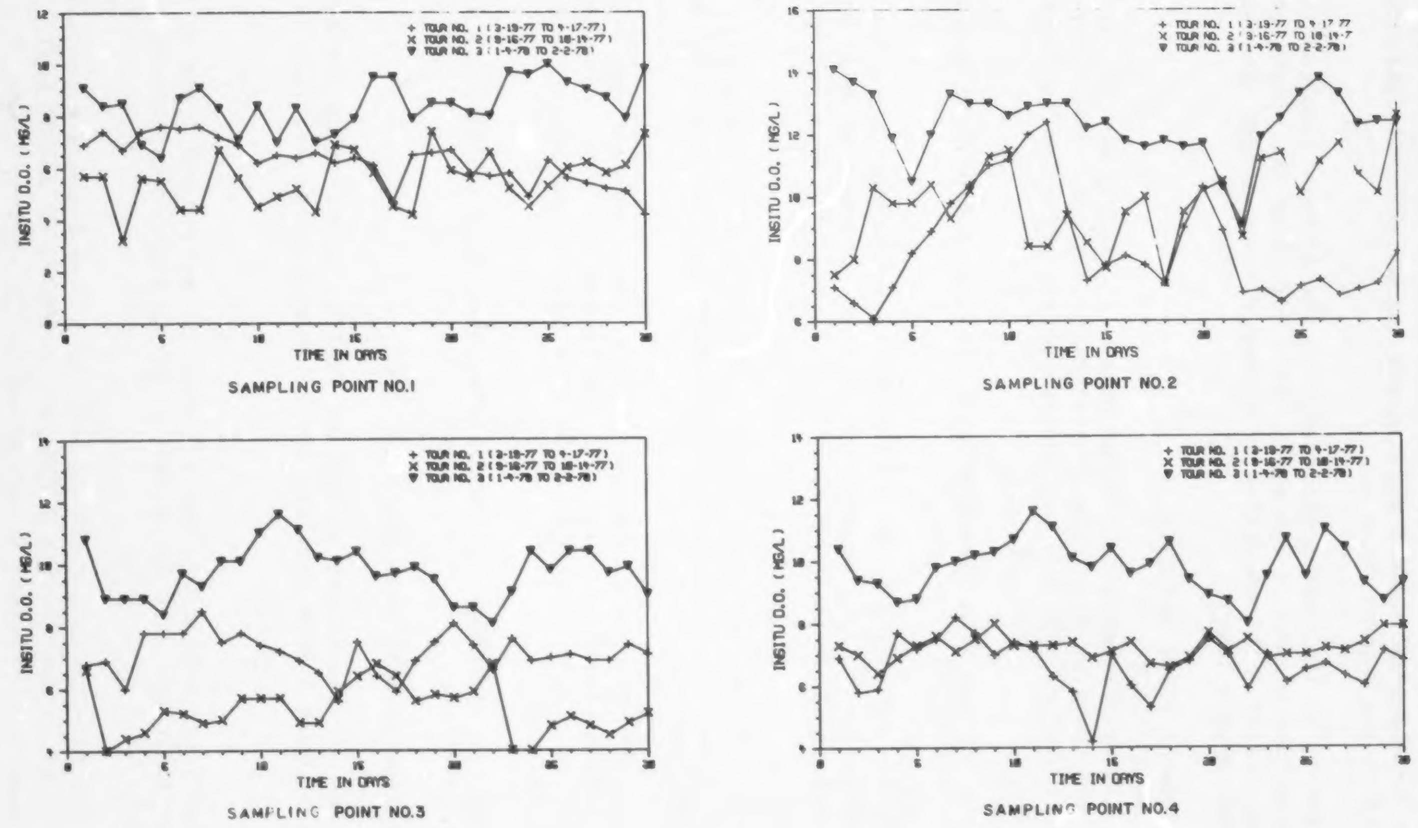


Figure 66. The relationship observed between in situ dissolved oxygen and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.

wastewater with a mean dissolved oxygen concentration of 6.7 mg/l. The increase in the overall mean to 10.2 mg/l in the lagoon effluent indicates an algal activity in the lagoon system.

The distribution of the lagoon effluent onto the filters resulted in a decrease in dissolved oxygen to 7.4 mg/l. This reflected the uptake of the oxygen in the filter. The chlorination system did not affect the filter effluent dissolved oxygen level.

Chemical Oxygen Demand (COD) and Soluble Chemical Oxygen Demand (SCOD)--

Mean total and soluble chemical oxygen demand concentrations for all sampling points and tours at Ailey are presented in Table 24. The daily variations in total and soluble COD concentrations are presented in Figures 67 and 68.

Variations in COD and SCOD were basically the same and will be discussed together.

Sampling Point #1--The lagoon influent COD concentrations increased between each tour resulting in a progressive increase in the tour mean values as follows: tour #1 - 111 mg/l, tour #2 - 161 mg/l and tour #3 - 203 mg/l (Table 24).

Along with the overall increase in COD, increase in SCOD occurred. The percentage of the total COD represented by SCOD went up from 23 percent during tour #1 to 68 percent during tour #3.

Sampling Point #2--The lagoon system effluent COD concentrations were more consistent during the three tours than the lagoon influent. Although moderate fluctuations can be observed in the total COD (Figure 67), the SCOD was relatively consistent.

Sampling Point #3--Although Figure 67 shows mild fluctuations, the tour means were very consistent.

The SCOD fluctuated more than the total COD.

Sampling Point #4--Reductions in COD and SCOD by chlorination may have occurred, but it is more likely that the reduction was due to settling in the contact tank.

Alkalinity--

Mean alkalinity concentrations for all sampling points and tours at Ailey are summarized in Table 24. The daily variations in alkalinity concentrations are shown in Figure 69.

Sampling Point #1--The alkalinity of the raw wastewater was essentially the same during tours #1 and #3 with respective means of 62 and 77 mg/l as $CaCO_3$ and a range of individual values of 46 to 130 mg/l as $CaCO_3$ (Figure 69).

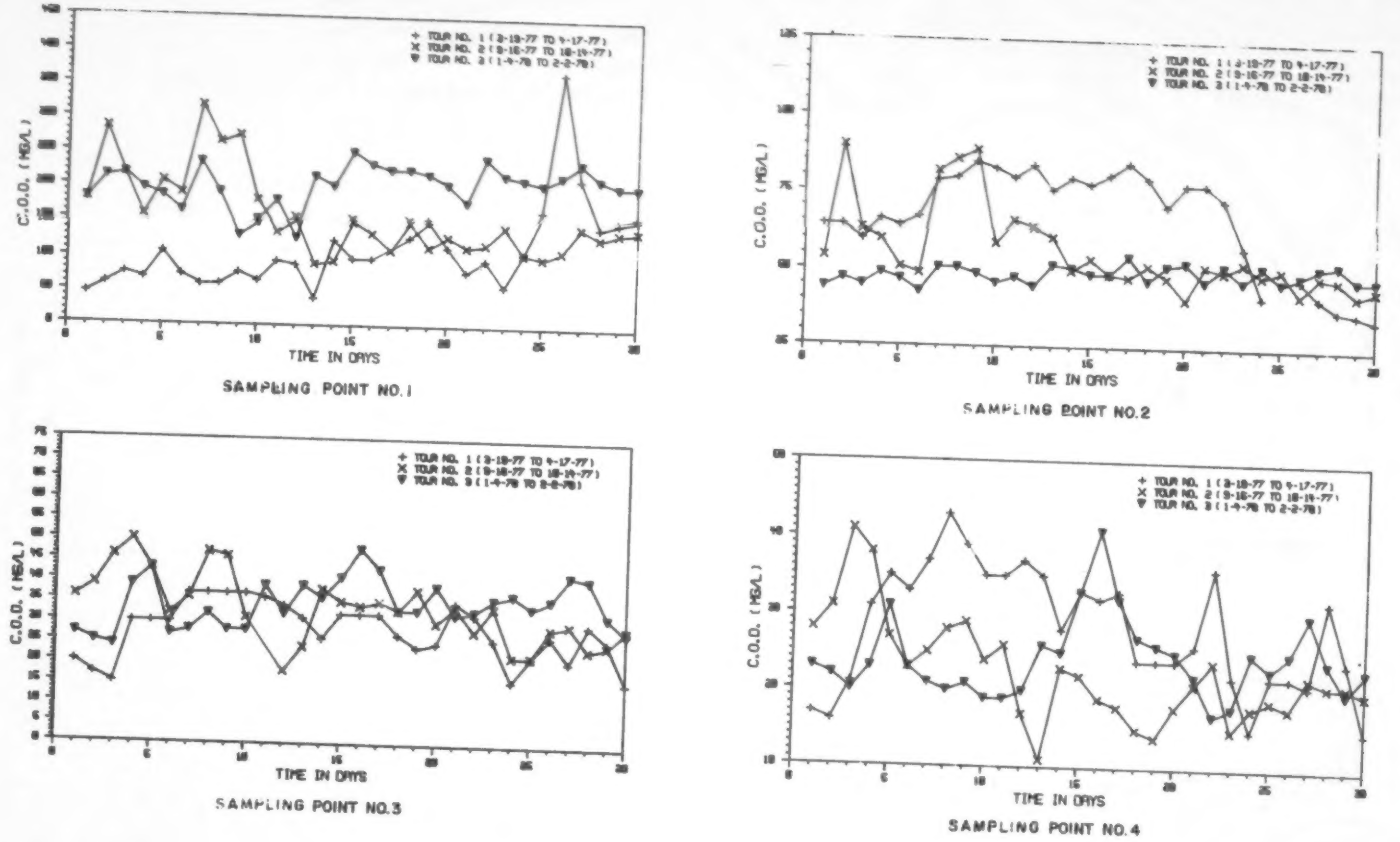


Figure 67. The relationship observed between chemical oxygen demand and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.

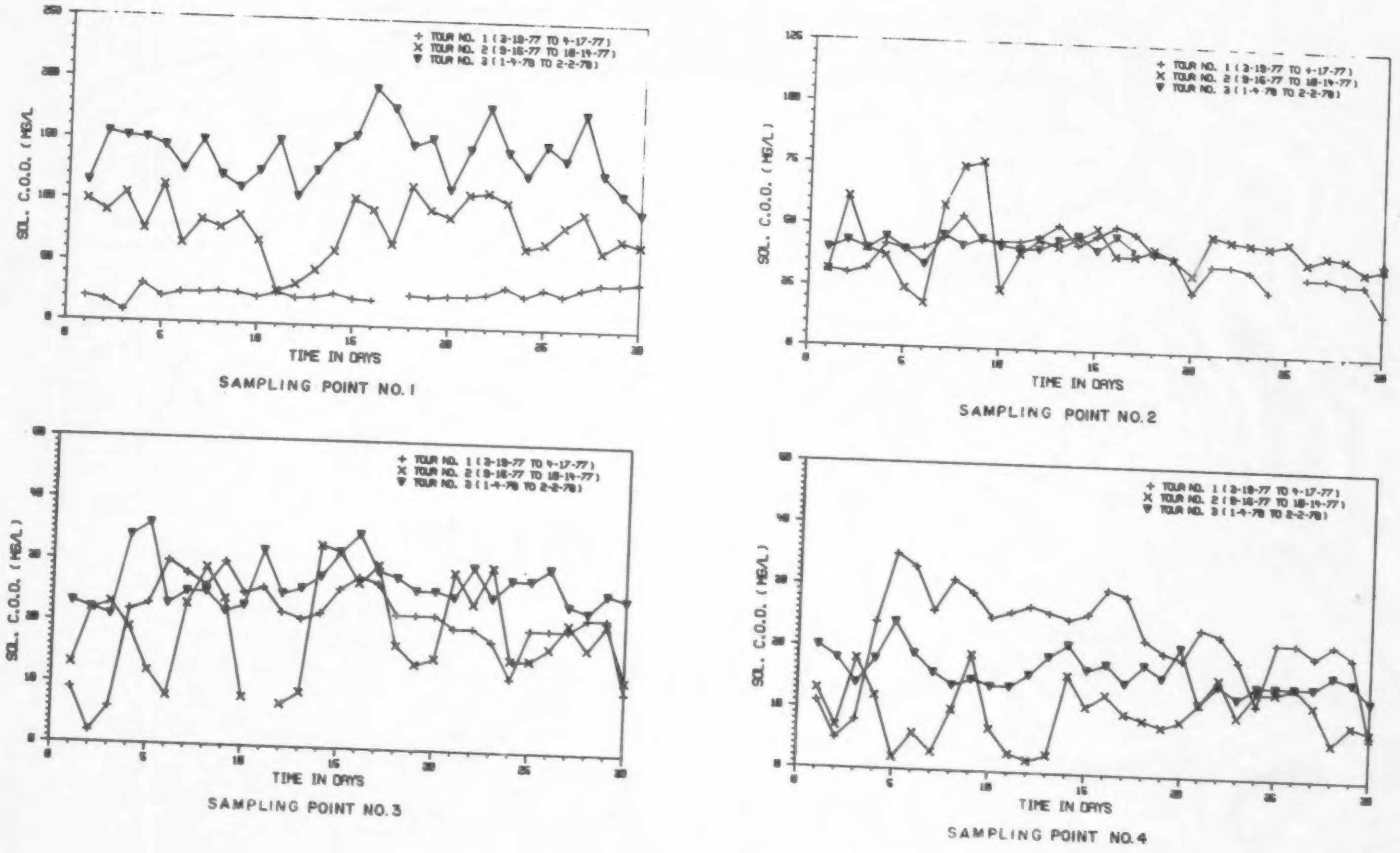


Figure 68. The relationship observed between soluble chemical oxygen demand and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.

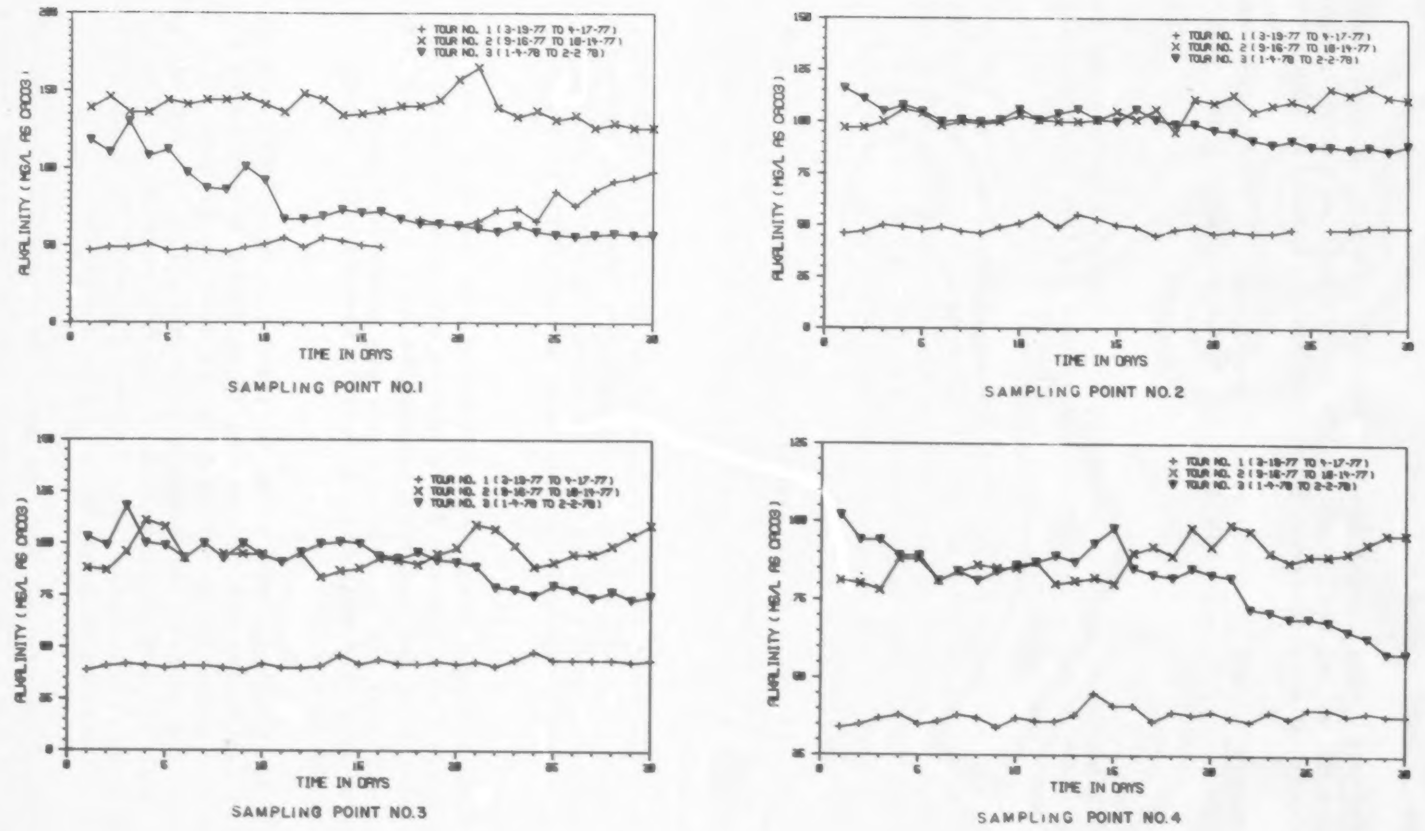


Figure 69. The relationship observed between alkalinity and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.

The values for tour #2 represent an increase in alkalinity caused by the recirculation of oxidation pond effluent.

Sampling Point #2--The lowest mean of 49 mg/l as $CaCO_3$ occurred during tour #1 and tours #2 and #3 had means of 105 and 99 mg/l as $CaCO_3$, respectively. Similar variations were observed in the influent alkalinity concentrations.

Sampling Points #3 and #4--Only slight reductions in alkalinity occurred as the wastewater passed through the filter. These variations are shown in Figure 69.

Total Phosphorus--

Mean total phosphorus concentrations for all sampling points and tours at Ailey are summarized in Table 24. Daily variations in the total phosphorus concentrations are shown in Figure 70.

Sampling Point #1--Tours #1 and #3 concentrations were very similar with tour mean concentrations ranging between 3 and 4 mg P/l. During tour #2 the total phosphorus influent concentrations exceeded the other tour means by a factor of two. The mean concentration for tour #2 was 7.8 mg P/l. This change is related to the seasonal low flows and the recirculation of the oxidation pond effluent.

Sampling Point #2--Tour #1 displayed the lowest mean of 1.42 mg P/l, and tours #2 and #3 had similar means of about 4.0 mg P/l. The difference in lagoon effluent phosphorus is seemingly related to the seasonal variations in the lagoon influent.

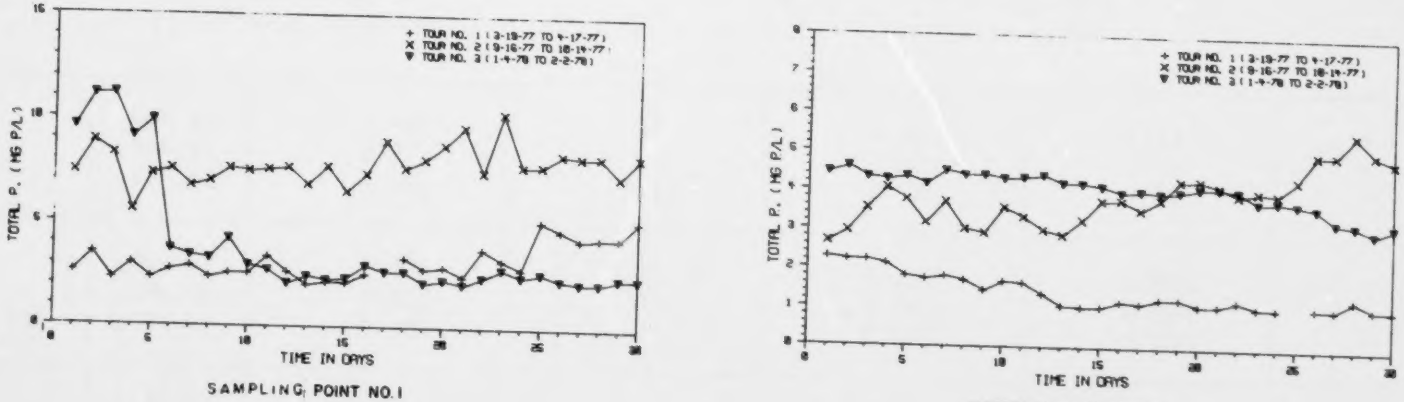
Sampling Points #3 and #4--The chlorination of the filtered water indicates another slight reduction in total phosphorus. The characteristics in Figure 70 for sampling points #3 and #4 are very similar to the lagoon effluent due to the slight removals at the last two sampling locations.

Nitrogen Forms--

General--Five nitrogen forms were monitored and the mean concentrations over the three tours for the Ailey system are shown in Table 26. The variations with time for the five parameters plus a plot of inorganic nitrogen (NO_2-N + NO_3-N) for the three tours are shown in Figures 71-76. A discussion of the major variations is presented by nitrogen form in the following paragraphs.

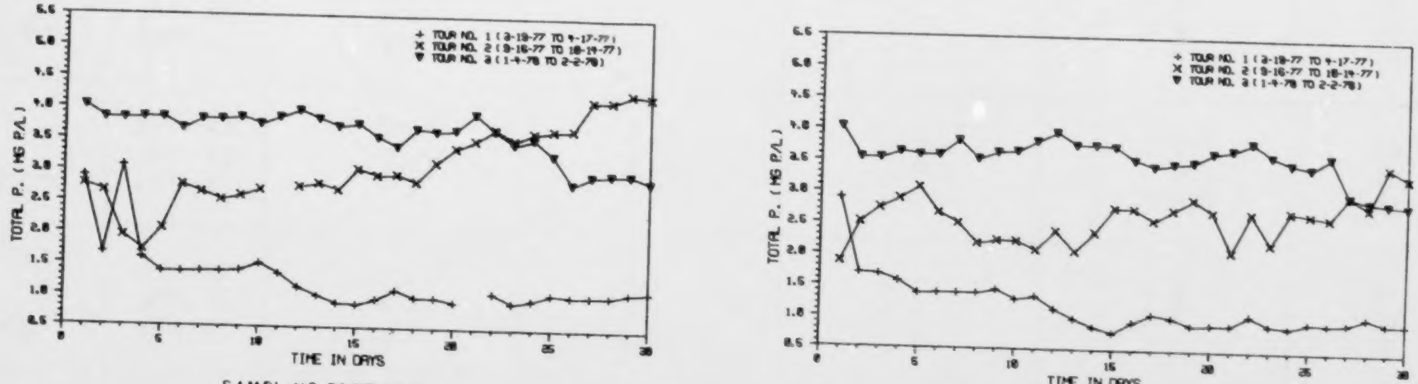
Total Kjeldahl Nitrogen--The total Kjeldahl nitrogen (TKN) concentrations in the raw wastewater fluctuated widely at times during tours #1 and #2 but remained essentially constant during tour #3 (Figure 71). The wide fluctuations and general increases in concentrations at the beginning of tour #2 and near the end of tour #1 are probably related to flow rate variations caused by infiltration into the sewer system. Mean concentrations for each tour and sampling station are shown in Table 26.

With the exception of tour #2, the lagoon effluent TKN concentrations were essentially stable. The TKN concentrations in the lagoon effluent during tour #1 were less than one half the concentrations during tours



SAMPLING POINT NO.1

• SAMPLING POINT NO.2



SAMPLING POINT NO.3

SAMPLING POINT NO.4

Figure 70. The relationship observed between total phosphorus and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.

TABLE 26. SUMMARY OF MEAN CONCENTRATIONS OF NITROGEN FORMS AT AILEY, GEORGIA

Nitrogen Form	Tour #	Lagoon Influent Concentration mg/l	Lagoon Effluent Concentration mg/l	Filter Effluent Concentration mg/l	Chlorinated Filter Effluent Concentration mg/l	Overall Removal %
TKN[a]	Tour #1	12.1	2.8	1.2	1.2	90
	Tour #2	15.8	8.8	4.8	2.6	84
	Tour #3	14.7	10.4	6.3	2.8	81
NH_3-N[b]	Tour #1	5.26	0.438	0.048	0.030	99
	Tour #2	7.37	0.047	0.087	0.044	99
	Tour #3	3.86	1.49	1.07	0.86	78
Org-N[c]	Tour #1	6.8	2.4	1.2	1.1	84
	Tour #2	8.4	8.8	4.8	2.6	69
	Tour #3	10.9	8.9	5.3	1.9	83
NO_2-N[d]	Tour #1	0.402	0.034	0.011	0.004	-
	Tour #2	0.902	0.009	0.069	0.014	-
	Tour #3	0.133	0.42	0.138	0.013	-
NO_3-N[e]	Tour #1	1.78	0.21	1.93	1.96	-
	Tour #2	1.59	0.01	3.06	2.28	-
	Tour #3	1.44	0.24	2.10	2.19	-

[a] TKN = total Kjeldahl nitrogen
[b] NH_3-N = ammonia nitrogen
[c] Org-N = organic nitrogen
[d] NO_2-N = nitrite nitrogen
[e] NO_3-N = nitrate nitrogen

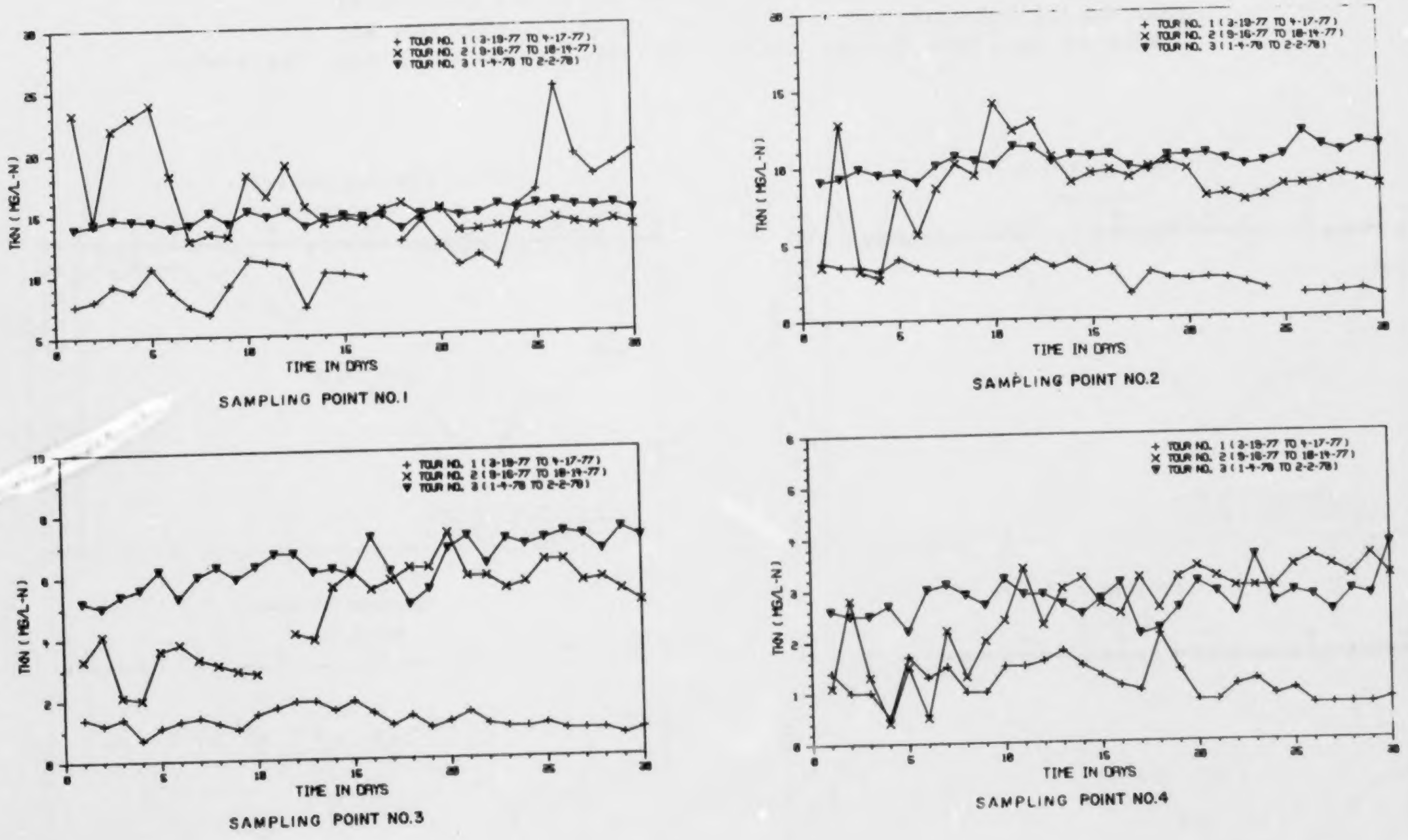
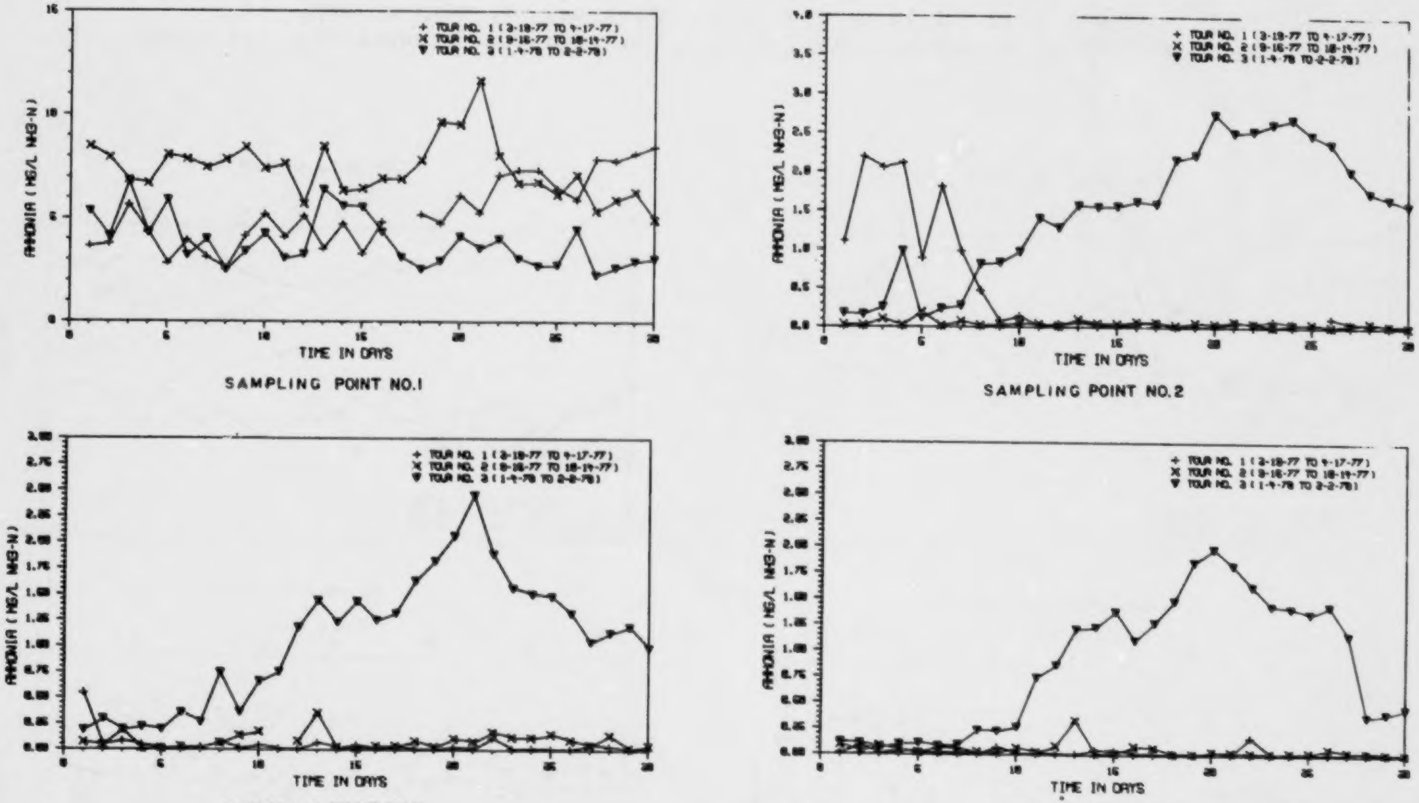


Figure 71. The relationship observed between total kjeldahl nitrogen and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.



SAMPLING POINT NO.1

SAMPLING POINT NO.2

SAMPLING POINT NO.3

SAMPLING POINT NO.4

Figure 72. The relationship observed between ammonia and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.

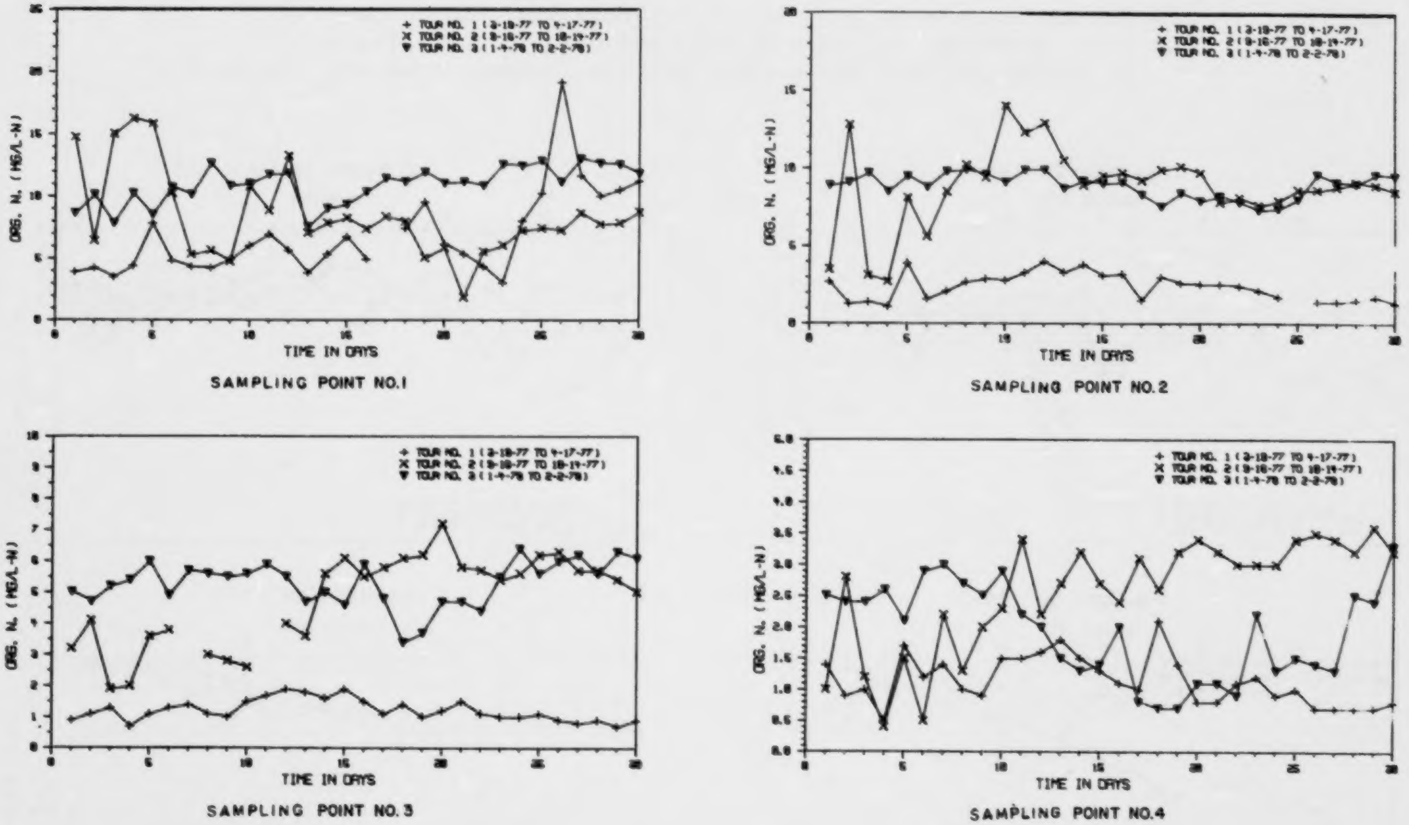


Figure 73. The relationship observed between organic nitrogen and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.

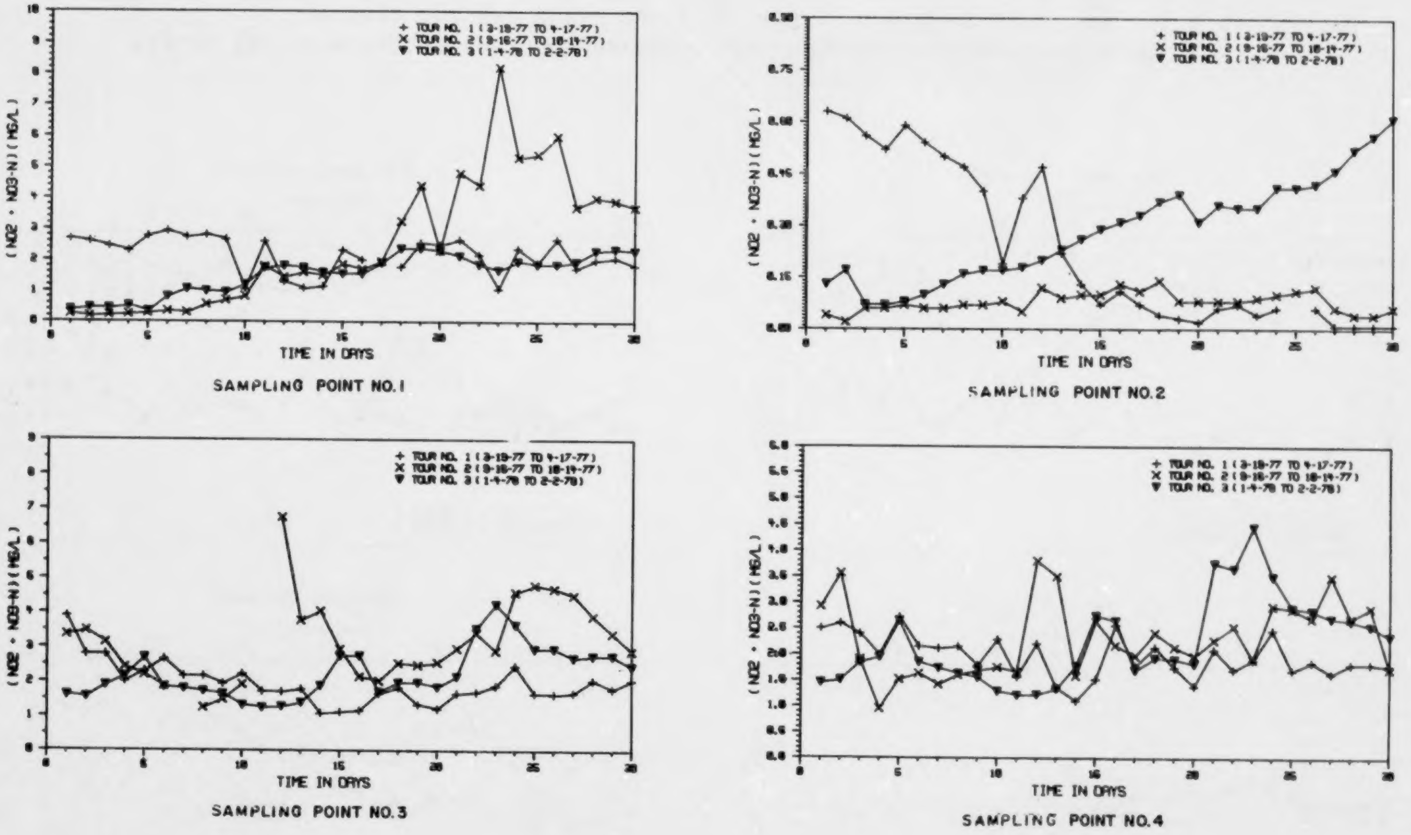
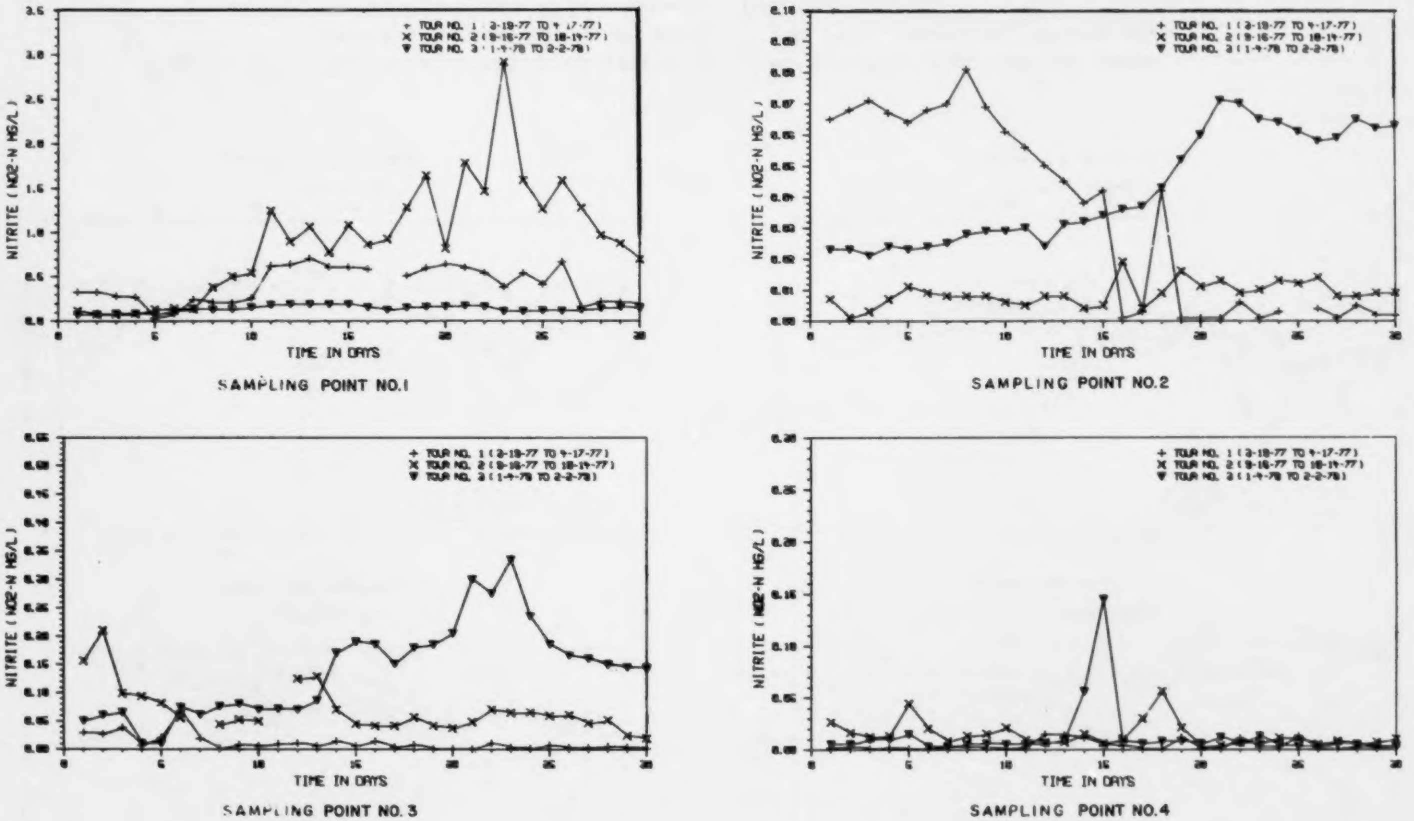


Figure 74. The relationship observed between the combined values of nitrite and nitrate and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.



SAMPLING POINT NO.1

SAMPLING POINT NO.2

SAMPLING POINT NO.3

SAMPLING POINT NO.4

Figure 75. The relationship observed between nitrite and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.

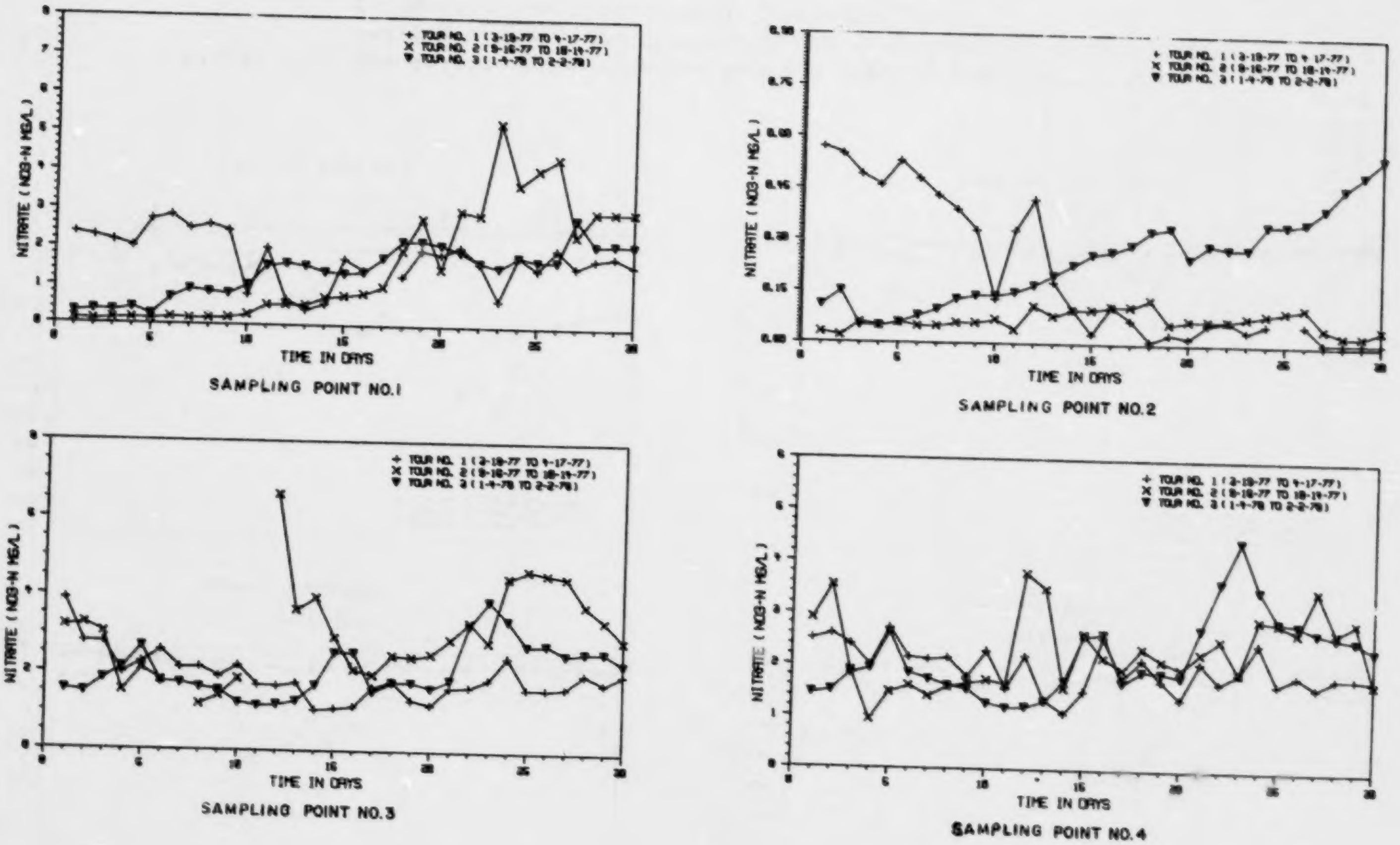


Figure 76. The relationship observed between nitrate and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.

#2 and #3. The TKN in the lagoon effluent during tour #1 was not affected by the rapid increase in influent concentration experienced near the end of the tour, but during tour #2 the lagoon effluent TKN concentration fluctuated indicating some influence by the higher concentrations of TKN in the influent to the lagoon.

TKN concentrations in the filter effluent and the chlorinated filter effluent followed the same trends observed for the lagoon effluent. TKN removal by the filters ranged from 39 to 57 percent and similar reductions were observed in the chlorinated filter effluent except during tour #1 when no change in mean TKN concentrations between the filtered and chlorinated filtered effluent was observed.

Ammonia Nitrogen--Mean ammonia-N concentrations in the lagoon influent were 5.5 mg N/l with a range of individual values from 2.55 to 11.65 mg N/l (Figure 72). During tours #1 and #3 only raw wastewater was added to the lagoons, but during tour #2 recirculation of lagoon effluent was practiced. The highest mean ammonia-N concentrations occurred during tour #2 when the flow rate was not diluted with infiltration.

The only significant change in ammonia-N concentrations took place in the lagoon system as shown in Figure 72 and Table 23.

The decline in ammonia-N removal shown in Figure 72 for tour #3 at sampling point #2 was caused by the decrease in detention time resulting from the high flow rates.

Organic Nitrogen--The tour means for the influent wastewater indicate that the organic nitrogen concentrations were increasing with each sampling period (Figure 73 and Table 26). The increase did not appear to be related to temperature changes, and perhaps there were new connections to the sewer containing high organic-N concentrations.

During tour #1 the best organic-N removal was obtained in the lagoon system with no statistically significant change by filtration or chlorination. During tours #2 and #3 the exact opposite of tour #1 was observed. Again, this difference cannot be explained by seasonal variations in temperature. Other seasonal variations may have contributed but specifics are not available to identify the factors.

Nitrite-N--The influent nitrite-N concentrations were <1 mg/l during tours #1 and #3 but tour #2 showed some concentrations of nitrite-N in the lagoon influent as high as 8 mg/l. The probable cause for the high values during tour #2 could be the recirculation of the oxidation pond effluent. From Figure 74 and Table 26 it can be seen that the nitrite-N concentrations changed little as the wastewater passed through the system.

Nitrate-N--The intermittent sand filters provided good nitrification. During tour #2 with low flowrates and hydraulic loadings, the highest mean nitrate-N concentration of 3.06 mg N/l was observed in the filter effluent. The chlorination of the filtered water produced no significant changes in the effluent nitrate-N concentrations (Figure 75).

Figure 76 is a plot of the inorganic nitrogen (sum of the NO_2-N and NO_3-N) concentrations at the four sampling stations. The same trends observed for the two constituents separately apply to the sums.

Nitrogen Mass Balance--Table 27 presents a mass balance performed on the Ailey system for all sampling stations and tours. Total nitrogen was reduced by 69 percent or more in the total system with the lagoons accounting for a significant percent of the reduction during all three tours: 78 (tour #1), 51 (tour #2), and 32 (tour #3) percent. Little nitrogen was removed by the filters, but considerable conversion of the ammonia-N occurred in the filters.

Algal Concentrations--

The total number of algae cells/ml measured at sampling points #2, #3 and #4 are presented in Figure 77. The algal genera identified each sampling day at each sampling location are presented in Table 28. The predominant algal genera varied with the season of the year.

Table 29 presents a summary of the mean algal concentrations at the three sampling points for the three tours. The highest algae concentrations in the lagoon and filter effluents occurred during the period with the greatest sunlight and highest temperatures.

Flow Rate--

The only source of flow data was the continuous flow recorder and tabulation device at the discharge end of the chlorine contact chamber (sampling point #4).

Sampling period #1 occurred at the end of the Spring, and the flow rate went from the high of 488 m^3/d in the beginning to the low of 125 m^3/d at the end with a mean of 291 m^3/d (Figure 78). The second tour was at the beginning of Fall and abnormally dry weather was experienced in the area. A relatively consistent flow rate was observed and the mean was 110 m^3/d. The third tour was during the rainy Winter months, and the mean flow rate was 397 m^3/d with a range of 223 m^3/d to 564 m^3/d. The overall mean discharge rate was 265 m^3/d for the three tours.

24-Hour Composite Sample pH and Dissolved Oxygen--

The 24-hour composite samples collected at all four sampling stations were monitored for pH and dissolved oxygen. The results are presented in Figures 79 and 80. The variations in pH value and dissolved oxygen concentrations reflect the same variations observed in the in situ samples.

TABLE 27. NITROGEN MASS BALANCE FOR AILEY, GEORGIA

Tour Number and Sample Location	Mean Values for Three Sampling Periods mg N/l					Overall Reduction %
	NH_3-N	Org-N	NO_2-N	NO_3-N	Total-N	
Tour #1 (Mar. 19-April 17)						
Lagoon Influent	5.26	6.8	0.402	1.78	14.2	-
Lagoon Effluent	0.438	2.4	0.034	0.21	3.1	78
Filter Effluent	0.048	1.2	0.011	1.93	3.2	77
Chlorinated Filter Effluent	0.030	1.1	0.004	1.96	3.1	78
Tour #2 (Sept. 15-Oct. 14)						
Lagoon Influent	7.37	8.4	0.902	1.59	18.3	-
Lagoon Effluent	0.047	8.8	0.009	0.01	8.9	51
Filter Effluent	0.087	4.8	0.069	3.06	8.0	56
Chlorinated Filter Effluent	0.044	2.6	0.014	2.28	4.9	73
Tour #3 (Jan. 4-Feb. 2)						
Lagoon Influent	3.86	10.9	0.133	1.44	16.3	-
Lagoon Effluent	1.49	8.9	0.42	0.24	11.1	32
Filter Effluent	1.07	5.3	0.138	2.10	8.6	47
Chlorinated Filter Effluent	0.86	1.9	0.013	2.19	5.0	69

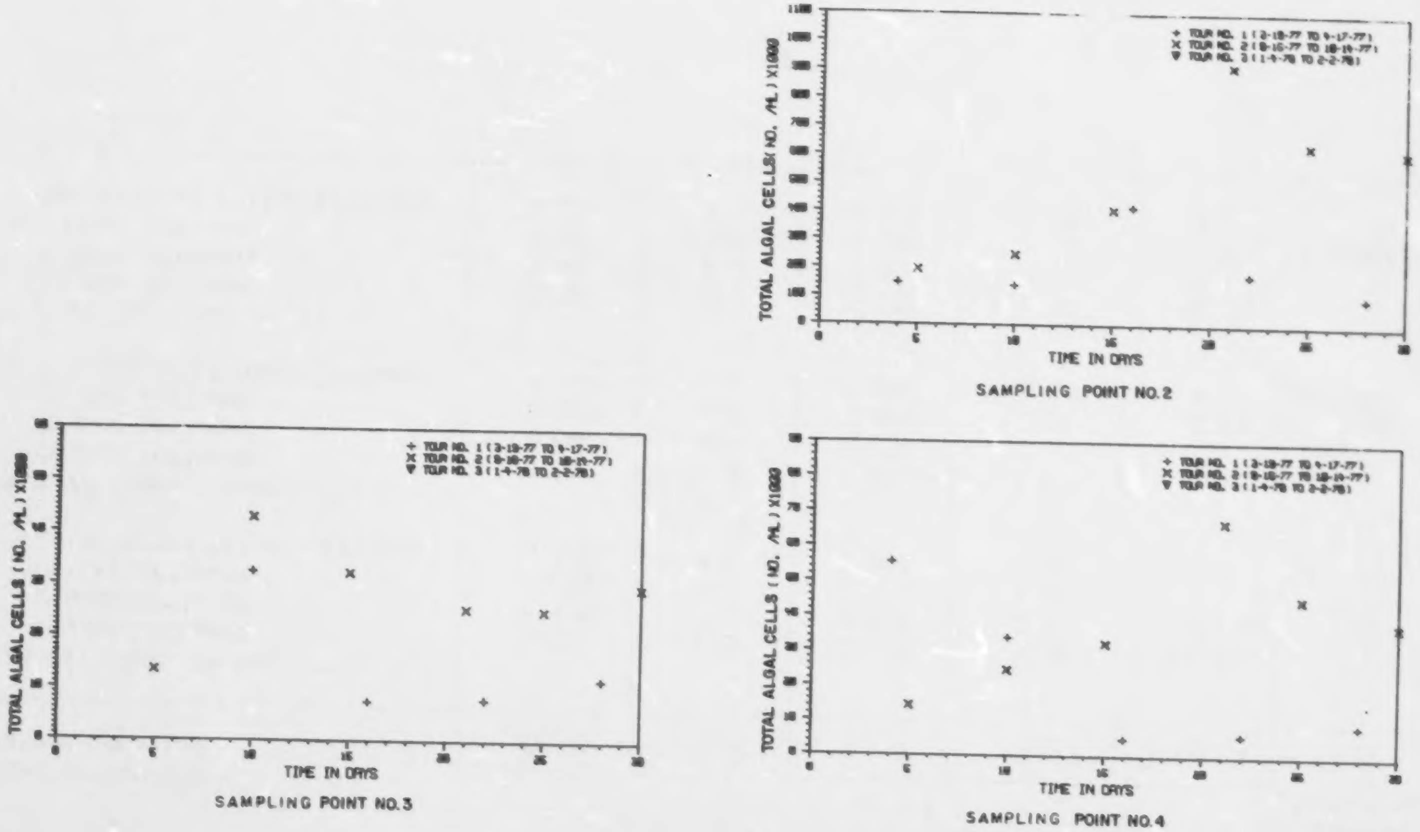


Figure 77. The relationship observed between total algal cells and time in days for the three tours at each of the three sampling points used to monitor the Ailey sewage treatment plant.

TABLE 28. AILEY #2 LAGOON EFFLUENT

Tour #1	Sampling Dates					
Algal Genera	3/22/77	3/28/77	4/3/77	4/9/77	4/15/77	
Euglena sp., cells/ml	-	-	-	-	-	
Sphaerocystis sp., cells/ml	65,229	30,106	20,000	-	43,890	
Scenedesmus sp., cells/ml	26,342	36,378	332,500	155,001	45,150	
Trachelomonas sp., cells/ml	53,939	26,342	24,500	10,164	1,254	
Ceratium sp., cells/ml	1,254	-	-	-	-	
Diatom, cells, ml	1,543	2,509	-	7,623	-	
Chlorella sp., cells/ml	-	45,158	41,520	5,082	3,762	
Cryptomonas sp., cells/ml	-	-	-	-	5,016	
Total Algae, cells/ml	148,307	140,493	418,520	177,870	99,072	
Tour #2	Sampling Dates					
Algal Genera	9/19/77	9/24/77	9/29/77	10/5/77	10/9/77	10/14/77
Ankistrodesmus sp., cells/ml	15,680	28,224	15,680	28,224	43,904	6,272
Diatom, cells/ml	15,680	6,272	-	-	-	-
Oscillatoria (filament) cells/ml	62,720	18,816	28,224	43,904	20,384	12,544
Sphaerocystis sp., cells/ml	56,448	128,576	216,384	620,928	94,080	12,544
Chlorella sp., cells/ml	43,904	65,856	122,304	197,568	457,856	580,160
Scenedesmus sp., cells/ml	-	-	25,088	21,952	18,816	-
Total Algae, cells/ml	194,432	247,744	407,680	912,576	635,040	611,520
Tour #3	Frozen Samples					

TABLE 28. AILEY #3 FILTER EFFLUENT

Tour #1	Sampling Dates					
Algal Genera	3/22/77	3/28/77	4/3/77	4/9/77	4/15/77	
Euglena sp., cells/ml	MS	314	-	-	-	
Sphaerocystis sp., cells/ml	MS	2,509	314	314	6,272	
Scenedesmus sp., cells/ml	MS	12,230	4,396	7,065	4,077	
Trachelomonas sp., cells/ml	MS	11,917	1,570	-	-	
Ceratium sp., cells/ml	MS	-	-	157	-	
Diatoms, cells/ml	MS	314	-	314	-	
Chlorella sp., cells/ml	MS	5,331	1,256	157	1,254	
Cryptomonas sp., cells/ml	MS	-	-	-	314	
Total Algae, cells/ml	MS	32,615	7,536	8,007	11,917	
Tour #2	Sampling Dates					
Algal Genera	9/19/77	9/24/77	9/29/77	10/5/77	10/9/77	10/14/77
Ankistrodesmus sp., cells/ml	196	3,450	1,882	941	627	784
Diatom, cells/ml	784	941	314	-	-	2,352
Oscillatoria (filament), cells/ml	784	627	941	627	-	196
Sphaerocystis sp., cells/ml	8,624	22,893	14,426	2,195	8,467	10,780
Chlorella sp., cells/ml	3,136	15,035	13,171	21,325	13,798	15,484
Scenedesmus sp., cells/ml	-	-	1,568	314	2,195	-
Total Algae, cells/ml	13,524	42,963	32,301	25,402	25,088	29,596
Tour #3	Frozen Samples					

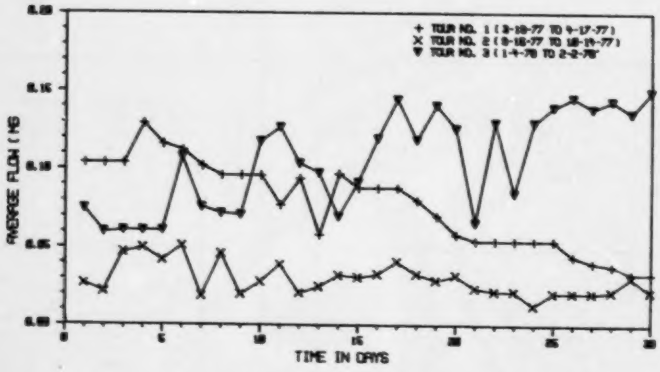
MS = missing sample.

TABLE 28. AILEY #4 CHLORINATED FILTER EFFLUENT

Tour #1	Sampling Dates					
Algal Genera	3/22/77	3/28/77	4/3/77	4/9/77	4/15/77	
Euglena sp., cells/ml	-	-	-	-	-	
Sphaerocystis sp., cells/ml	22,579	5,018	157	-	4,077	
Scenedesmus sp., cells/ml	31,360	13,171	3,611	5,809	3,140	
Trachelomonas sp., cells/ml	1,568	12,230	942	-	-	
Ceratium sp., cells/ml	-	-	-	-	-	
Diatom, cells/ml	-	314	-	157	-	
Chlorella sp., cells/ml	-	3,140	314	157	1,568	
Cryptomonas sp., cells/ml	-	-	-	-	314	
Total Algae, cells/ml	55,507	33,873	5,024	6,123	9,099	
Tour #2	Sampling Dates					
Algal Genera	9/19/77	9/24/77	9/29/77	10/5/77	10/9/77	10/14/77
Ankistrodesmus sp., cells/ml	1,882	3,136	1,882	3,763	941	941
Diatom, cells/ml	314	1,256	627	314	235	314
Oscillatoria (filament), cells/ml	2,195	1,882	941	2,195	1,176	627
Sphaerocystis sp., cells/ml	8,467	4,390	9,722	25,715	9,643	1,568
Chlorella sp., cells/ml	1,254	12,544	17,875	34,182	32,693	34,182
Scenedesmus sp., cells/ml	-	1,254	1,254	941	470	-
Total Algae, cells/ml	14,112	24,461	32,301	67,110	45,158	37,632
Tour #3	Frozen Samples					

TABLE 29. MEAN ALGAL CONCENTRATIONS, CELLS/ml

Sample Location	Tour #1	Tour #2	Tour #3
Lagoon Effluent	197,000	501,000	Frozen
Filter Effluent	15,000	28,000	
Chlorinated Effluent	21,900	36,800	
Percent Removal	88.8	92.7	



SAMPLING POINT NO.4

1 MGD = 3785 m^3/d

Figure 78. The relationship observed between average daily flow and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.

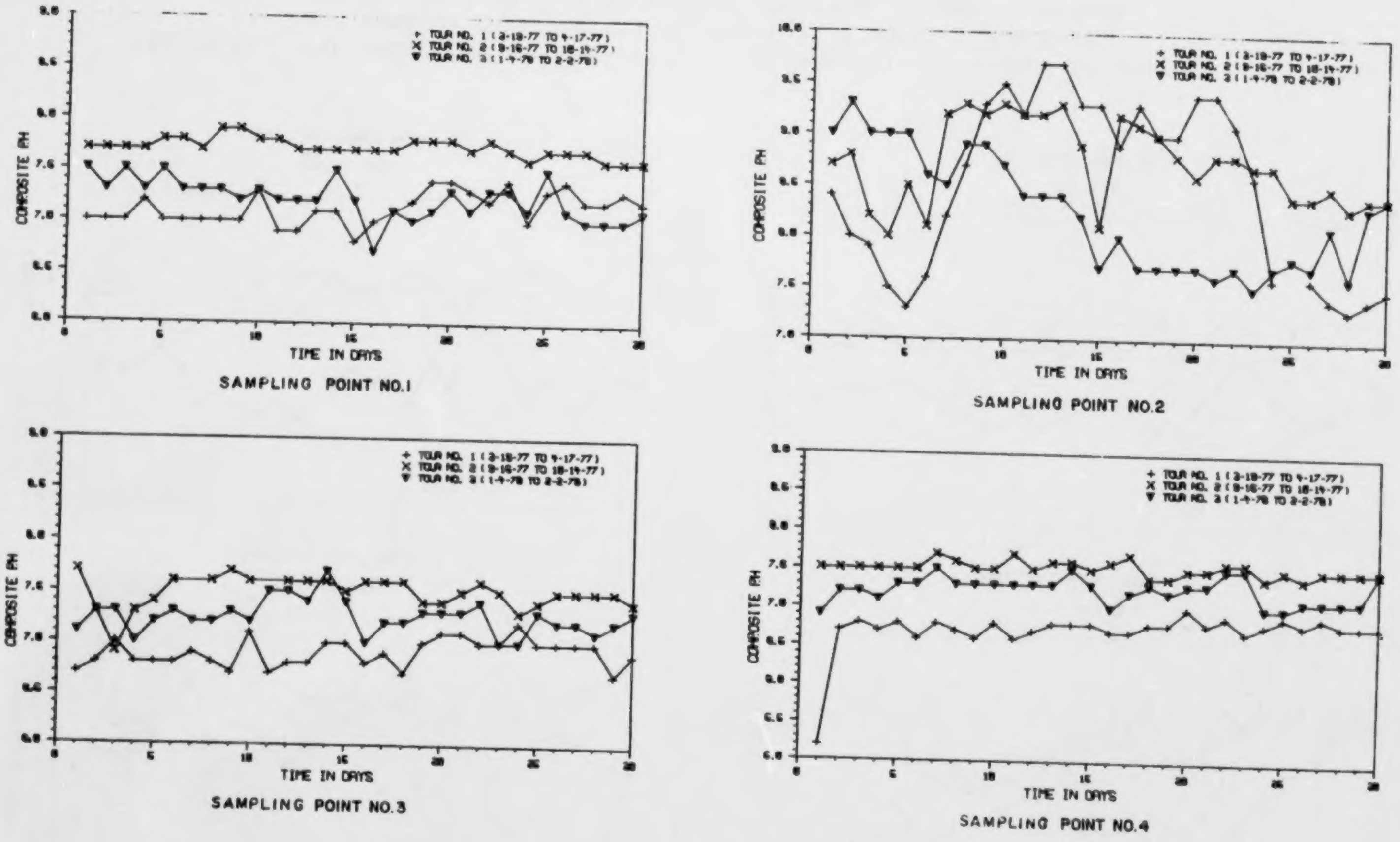


Figure 79. The relationship observed between composite pH and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.

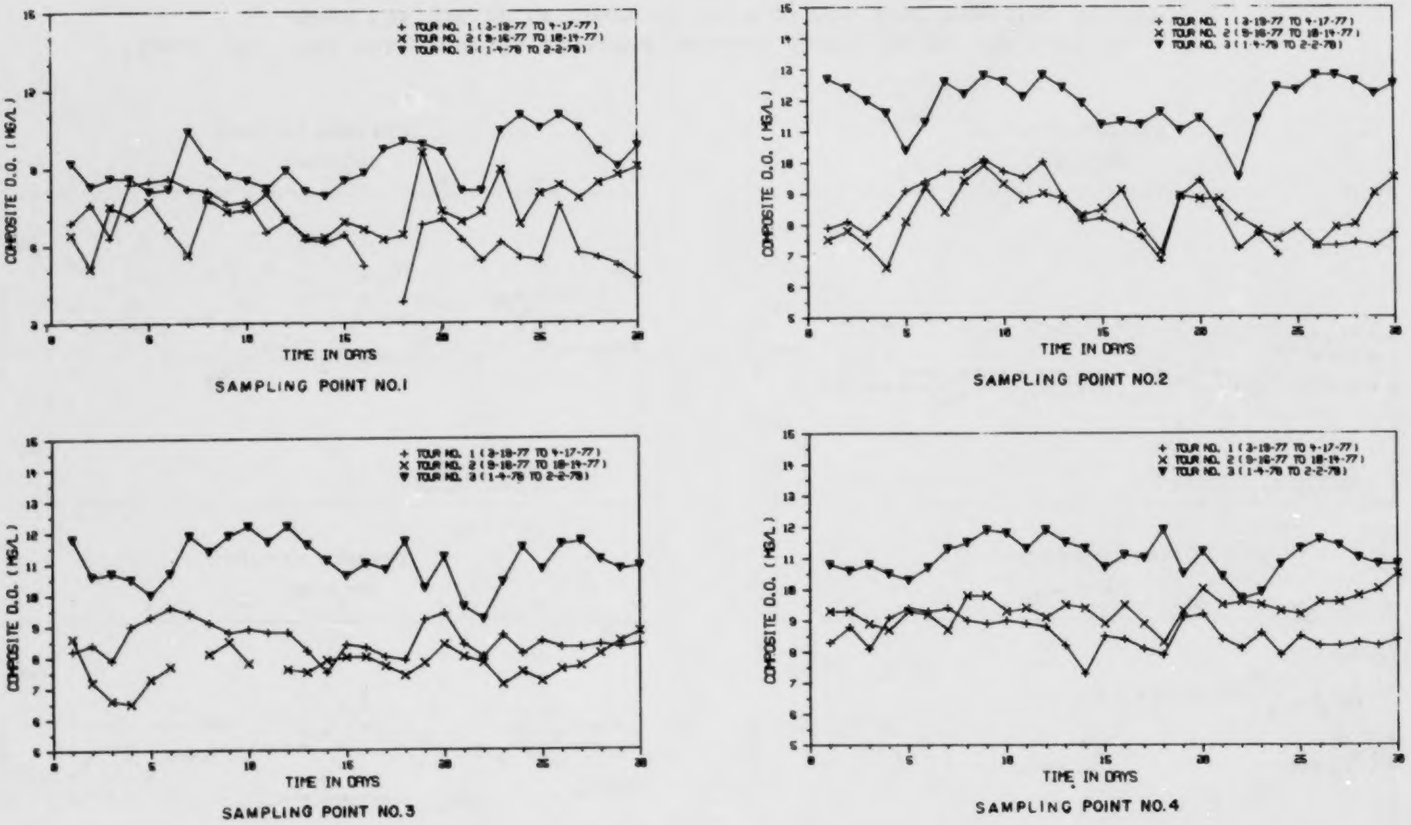


Figure 80. The relationship observed between composite dissolved oxygen and time in days for the three tours at each of the four sampling points used to monitor the Ailey sewage treatment plant.

SECTION 7

COMPARISON OF PERFORMANCE WITH FEDERAL STANDARDS

GENERAL

The performances of the three systems are compared with the 1972 Federal Secondary Treatment Standards shown in Table 3. Each of the systems was analyzed as to its ability to meet the federal discharge requirements.

BIOCHEMICAL OXYGEN DEMAND

Table 30 presents a summary of the mean five day biochemical oxygen demand (BOD_5) concentrations measured during each tour at the three sites. Influent and effluent concentrations and removal efficiencies for the lagoon system, intermittent sand filters and the overall facility are presented.

The lagoon systems at the three sites provided similar BOD_5 removal efficiencies considering seasonal variations with the exceptions of the Ailey, Georgia, facility during the third sampling period. The climatic conditions at Ailey, Georgia, during certain periods of the year result in high precipitation rates, and the lagoon system is sometimes hydraulically overloaded. This resulted in a significant decrease in efficiency during this period.

The efficiency of the intermittent sand filtration of the lagoon effluent varied significantly between the three facilities and even between the tours at each site. During the high hydraulic loadings of tour #3, a slight decrease in BOD_5 removal by the filters was observed.

The highest filter removal of BOD_5 was observed at Mt. Shasta during tour #2, when the filters were operated strictly according to the design engineer's recommended operating procedure. In contrast, the poorest BOD_5 removal at Mt. Shasta was observed during the first tour when the operation of the system was varied.

In five of the nine sampling periods, the removal exceeded 93 percent. All of the facilities demonstrated an ability to meet the federal secondary discharge requirements for BOD_5 (30 mg/l). The only marginal situation existed at the Ailey, Georgia, facility during tour #3 when the 30-day BOD_5 removal was 84 percent in relation to the requirements of 85 percent removal.

TABLE 30. SUMMARY OF TOUR MEANS FOR BOD_5

Sampling Site	Tour #	5 Day Biochemical Oxygen Demand, mg/l								
		Lagoon System			Intermittent Sand Filters			Overall Facility[a]		
		Influent	Effluent	% Removal	Influent	Effluent	% Removal	Influent	Effluent	% Removal
Mt. Shasta, California	Tour #1	110	26	76	26	21	19	110	14	87
	Tour #2	121	19	84	19	4	80	121	3	98
	Tour #3	110	20	82	20	7	65	110	4	96
Moriarty, New Mexico	Tour #1	133	35	74	35	20	43	133	20	85
	Tour #2	135	22	84	22	10	54	135	10	93
	Tour #3	177	32	82	32	21	34	177	21	88
Ailey, Georgia	Tour #1	63	11	83	11	4	64	63	3	95
	Tour #2	76	20	74	20	5	75	76	4	95
	Tour #3	63	34	46	34	14	59	63	10	84

[a] Chlorinated effluent.

The 30-day means for the three sites ranged from 3 to 21 mg/l with a range of 84 to 98 percent removal. The 7-day means never exceeded the 45 mg/l maximum concentration.

Intermittent sand filtration played a significant role in the ability of the three treatment facilities to meet the BOD_5 discharge requirements. The most significant result of intermittent sand filtration was observed at the Moriarty, New Mexico, facility when the lagoon discharge 30-day mean BOD_5 concentrations were greater than 30 mg/l two out of the three sampling periods. Lagoon effluent at the Mt. Shasta facility provided the 30-day, 30 mg/l and 7-day 45 mg/l means but could not produce a 30-day 85 percent removal. Without the intermittent sand filters, none of the three sites during the three sampling periods could meet the federal discharge requirements for BOD_5.

SUSPENDED SOLIDS

A summary of the mean suspended solids concentrations for the three facilities is presented in Table 31. The suspended solids removal for the two major subsystems of each system are included for comparative purposes.

The removal of suspended solids by the lagoon system appears to be fairly consistent between the three sites with some significant seasonal variations easily identified. The range of removal varied from the low of 20 percent produced by the Mt. Shasta facility during tour #2 (summer algal growth) to a high of 73 percent at the Ailey facility during tour #1 (low algal growth).

The intermittent sand filtration of the lagoon effluent would be expected to provide the most significant reduction of suspended solids and it did with effluent suspended solids means ranging from 11 mg/l to 26 mg/l. The removals were consistently above 50 percent with five out of the nine sampling periods above 75 percent. The exception was the first tour at the Mt. Shasta facility when only 30 percent removal of suspended solids was observed. This low removal was attributable to the frozen filters which created short circuiting allowing the suspended solids to pass around the filter media.

The Moriarty filters consistently produced the highest removals of greater than or equal to 80 percent during all three tours with a maximum of 89 percent during the last tour. This high suspended solids removal is related to the filter media effective size of 0.20 mm, the lowest of the three sites. The progressive increase in removal efficiency displayed by the Moriarty filters reflects the build-up of filtered material on the filter surface.

The overall removal of suspended solids by the three facilities was about 86 percent with a range of 74 percent to 95 percent, and a range of mean discharge suspended solids concentrations of 8 to 21 mg/l. The first sampling period at the Mt. Shasta facility produced only a 75 percent reduction in suspended solids which was due to frozen filters. During tour #3 at

TABLE 31. SUMMARY OF TOUR MEANS FOR SUSPENDED SOLIDS

Sampling Site	Tour #	Suspended Solids Concentration, mg/l								
		Lagoon System			Filter System			Overall Facility[a]		
		Influent	Effluent	% Removal	Influent	Effluent	% Removal	Influent	Effluent	% Removal
Mt. Shasta, California	Tour #1	85	37	56	37	26	30	85	21	75
	Tour #2	86	69	20	69	13	81	86	13	85
	Tour #3	73	33	55	33	11	67	73	11	85
Moriarty, New Mexico	Tour #1	174	83	52	83	17	80	174	17	90
	Tour #2	128	89	30	89	15	83	128	15	88
	Tour #3	155	71	54	71	8	89	155	8	95
Ailey, Georgia	Tour #1	116	31	73	31	14	55	116	13	89
	Tour #2	148	48	68	48	11	77	148	8	95
	Tour #3	65	49	25	49	19	61	65	17	74

[a] Chlorinated effluent.

the Ailey, Georgia, facility a 74 percent reduction of influent suspended solids was observed and this was caused by the heavy seasonal precipitation.

A review of Table 31 shows again that the intermittent sand filters were necessary in all nine sampling periods to produce an effluent with 30 mg/l or less of suspended solids.

FECAL COLIFORM BACTERIA

Table 32 presents the fecal coliform bacteria mean populations for the lagoon effluent, the filter effluent, and the chlorinated effluent. In the case of the Moriarty facility where chlorination is practiced prior to applying wastewater to the filter, the numbers listed in Table 32 under the reading "chlorinated effluent" are for chlorinated lagoon effluent instead of chlorinated filter effluent as at the other two sites.

The high mean fecal coliform concentrations in the Moriarty lagoon effluent during tour #2 were caused by the experimentation to determine the effect on filter performance of pre-chlorination. Chlorination was practiced intermittently during this period of operation. The disinfection systems at the Mt. Shasta, California, and Ailey, Georgia, facilities provided excellent removal of fecal coliforms.

The intermittent sand filter effluents at the Mt. Shasta, California; Moriarty, New Mexico; and Ailey, Georgia, facilities contained a mean fecal coliform concentration of less than 100 organisms/100 ml without chlorination for all nine tours.

pH VALUE

The presentation in Table 33 of the ranges of effluent of in situ pH values for each tour at the three sites illustrates the ability of the three facilities to meet the 1972 federal discharge requirement that pH values range between 6.0 and 9.0. Of the 266 sampling days during the nine sampling periods, there were only three days when the effluent pH dropped below 6.0. The first two days occurred during tour #1 at Mt. Shasta, California, when the effluent pH value dropped to 5.9 and 5.7. This shift is most probably the result of over chlorination. The third day with a pH value below the requirement was the first day of tour #1 at Ailey, Georgia, and this was most likely an erroneous reading.

SUMMARY

All three systems satisfied the 1972 Federal Secondary Treatment Discharge Standards for biochemical oxygen demand (BOD_5), except the Ailey, Georgia, facility during tour #3 when the 30 day BOD_5 removal was only 84 percent instead of the required 85 percent removal. The 30 day mean effluent BOD_5 concentrations for all three systems ranged from 3 to 21 mg/l with a

TABLE 32. SUMMARY OF FECAL COLIFORM GEOMETRIC MEAN POPULATIONS

Sample Site	Tour #	Fecal Coliform Concentrations, counts/100 ml		
		Lagoon Effluent	Filter Effluent	Chlorinated Effluent
Mt. Shasta, California	Tour #1	721	53	<1
	Tour #2	20	2	<1
	Tour #3	179	37	5
Moriarty, New Mexico	Tour #1	27	8	2[a]
	Tour #2	781	91	51[a]
	Tour #3	62	2	<1[a]
Ailey, Georgia	Tour #1	8	3	<1
	Tour #2	9	1	<1
	Tour #3	148	21	<1

[a] Chlorinated lagoon effluent which was then applied to the intermittent sand filter.

TABLE 33. SUMMARY OF RANGE OF EFFLUENT pH VALUES

Tour #	pH Values, units		
	Mt. Shasta, California	Moriarty, New Mexico	Ailey, Georgia
Tour #1	5.7 - 7.0	7.5 - 8.5	6.3 - 6.8
Tour #2	6.4 - 7.3	7.9 - 8.3	7.0 - 7.4
Tour #3	6.3 - 7.3	7.7 - 8.2	6.5 - 7.2

percentage removal range of 84 to 98 percent. The 7 day mean effluent BOD_5 concentrations for all three systems never exceeded the 45 mg/l maximum concentration requirement.

All three systems satisfied the 1972 Federal Secondary Treatment Discharge Standards for suspended solids, except that 85 percent removal of the influent suspended solids concentration was not accomplished during two of the nine sampling periods. The 30 day mean effluent suspended solids concentrations for all three systems ranged from 8 to 21 mg/l, and the 7 day mean effluent suspended solids effluent concentrations for all three systems never exceeded the 45 mg/l maximum concentration requirement.

All three systems satisfied the 1972 Federal Secondary Treatment Discharge Standard for fecal coliform bacteria throughout the entire study. At no time did the 30 day geometric mean effluent fecal coliform concentration of the three systems exceed 200 organisms/100 ml, or the 7 day geometric mean effluent fecal coliform concentration of the three systems exceed 400 organisms/100 ml. Although all three sites practiced effluent chlorination, the effluent fecal coliform standard was met by the intermittent sand filter prior to final effluent disinfection with chlorine.

Of the 256 sampling days during the nine sampling periods, there were only three days in which the effluent pH of the three systems did not satisfy the 1972 Secondary Treatment Discharge Standard (effluent pH range between 6.0 and 9.0). Two of these three measurements were probably a result of over chlorination and the third measurement was most likely an analytical error.

The 1972 Federal Secondary Treatment Discharge Standards were satisfied by all three systems, except that the 85 percent removal of the influent suspended solids concentration was not accomplished during two of the nine sampling periods.

SECTION 8

STATISTICAL COMPARISONS

GENERAL

A statistical analysis of the intermittent sand filter effluent tour mean values of the parameters used to compare the overall performance of the three sampling sites was performed. The Duncan Multiple Range Test (Duncan, 1955) with a modification for means with unequal replications developed by Kramer (1956) was used to compare the tour means for significant differences at the 95 percent confidence level. Biochemical oxygen demand (BOD_5), soluble biochemical oxygen demand ($SBOD_5$), suspended solids (SS), volatile suspended solids (VSS), and fecal coliform bacteria mean concentrations were compared. The results of the analyses are presented in the following paragraphs.

BIOCHEMICAL OXYGEN DEMAND (BOD_5)

The results of the statistical analysis of the mean BOD_5 concentrations in the intermittent sand filter effluents are presented in Table 34. The mean BOD_5 concentrations for the Mt. Shasta facility during tours #2 and #3 and the Ailey facility mean values for tours #1 and #2 were not significantly different at the 95 percent confidence level. This group represents the best performance under proper operational techniques for both of the systems.

Although ranked near the upper end of the lower concentration group, the effluent concentration during tour #2 at Moriarty represents the best performance by the Moriarty system in terms of BOD_5 reduction. Also during tour #2 the applied BOD_5 concentrations were the lowest for the three tours at Moriarty. Isolation of the Ailey tour #3 mean BOD_5 concentration and its statistical difference from the other two Ailey means is caused by the reduction in removal efficiency due to hydraulic overloading of the system.

The last group with the three highest tour means contains data collected during Mt. Shasta tour #1 and Moriarty tours #1 and #3. The high mean for Mt. Shasta tour #1 was the result of the frozen filter problem described earlier. Poor BOD_5 removal during tours #1 and #3 at Moriarty can be attributed to the relatively high applied BOD_5 values and the inhibition of bacterial activity in the filters caused by pre-chlorination of lagoon effluent prior to application to the intermittent sand filters.

TABLE 34. COMPARISON OF MEAN BOD_5 (mg/l) CONCENTRATIONS USING DUNCAN'S MULTIPLE RANGE TEST[a]

Treatment	MS2	A1	A2	MS3	M2	A3	M1	MS1	M3
Mean BOD_5 mg/l	3.6	4.2	4.9	5.9	9.4	14.4	19.3	19.8	21.1
No. of Samples	29	30	30	15	30	30	30	30	30

CODE: MS-1 Mt. Shasta - Tour #1
MS-2 Mt. Shasta - Tour #2
MS-3 Mt. Shasta - Tour #3
M-1 Moriarty - Tour #1
M-2 Moriarty - Tour #2
M-3 Moriarty - Tour #3
A-1 Ailey - Tour #1
A-2 Ailey - Tour #2
A-3 Ailey - Tour #3

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[a] Means underlined with a common line are not significantly different (95% level).

SOLUBLE BIOCHEMICAL OXYGEN DEMAND ($SBOD_5$)

The results of the statistical analysis of the mean $SBOD_5$ concentrations in the intermittent sand filter effluents are presented in Table 35. At the lower concentrations of the ranked means the soluble biochemical oxygen demand for the Mt. Shasta facility and the Ailey facility, except for tour #3 at Ailey, do not vary significantly at the 95 percent confidence level. The exclusion of Ailey tour #3 again reflects the hydraulic overload experienced during that period of monitoring.

Moriarty filter effluent $SBOD_5$ tour mean concentrations were significantly different from the other two filter effluents. The difference was the pre-chlorination of the applied wastewater which inhibited SBOD removal. $SBOD_5$ represents that portion of total BOD_5 that cannot be physically

TABLE 35. COMPARISON OF MEAN $SBOD_5$ (mg/l) CONCENTRATIONS[a]

Treatment	MS1	MS3	A2	A1	MS1	M2	A3	M3	M1
Mean $SBOD_5$ mg/l	3.1	3.5	4.2	4.7	4.7	6.9	8.3	17.0	20.5
No. of Samples	29	15	30	30	30	30	30	30	30

CODE: MS-1 Mt. Shasta - Tour #1
MS-2 Mt. Shasta - Tour #2
MS-3 Mt. Shasta - Tour #3
M-1 Moriarty - Tour #1
M-2 Moriarty - Tour #2
M-3 Moriarty - Tour #3
A-1 Ailey - Tour #1
A-2 Ailey - Tour #2
A-3 Ailey - Tour #3

---

[a] Means underlined with a common line are not significantly different (95% level).

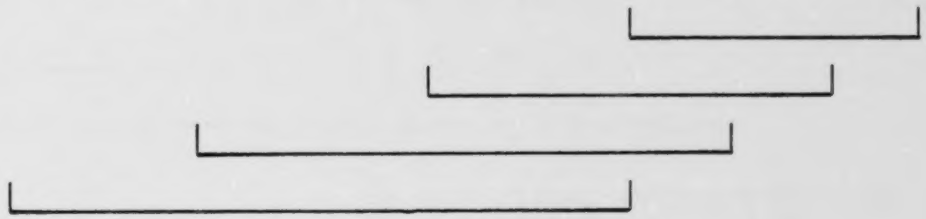
removed; thus, reduction of $SBOD_5$ must be achieved by biological activity in the filter media. The evidence in support of inhibition is reflected in the significantly different tour means for Moriarty at the higher concentrations of the ranked means.

SUSPENDED SOLIDS

Table 36 presents the statistical analysis of the mean suspended solids concentrations in the intermittent sand filter effluents. The first six tour means did not differ statistically at the 95 percent confidence level. These six tour means represent two tours at each of the three sites evaluated. The excluded three means do not differ (95 percent); however, there is some overlap with the six non-differing means with the total exclusion of only the highest concentration. The excluded tour means represent the poorest performance at each site. The Ailey tour #3 performance has been associated

TABLE 36. COMPARISON OF MEAN SUSPENDED SOLIDS CONCENTRATIONS USING DUNCAN'S MULTIPLE RANGE TEST[a]

Treatment	M3	A2	MS3	MS2	A1	M2	A3	M1	MS1
Mean SS mg/l	8.4	10.0	10.9	12.9	14.4	14.6	18.9	22.3	25.9
No. of Samples	30	30	15	29	30	30	30	30	30



CODE: MS-1 Mt. Shasta - Tour #1
MS-2 Mt. Shasta - Tour #2
MS-3 Mt. Shasta - Tour #3
M-1 Moriarty - Tour #1
M-2 Moriarty - Tour #2
M-3 Moriarty - Tour #3
A-1 Ailey - Tour #1
A-2 Ailey - Tour #2
A-3 Ailey - Tour #3

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[a] Means underlined with a common line are not significantly different (95% level).

with the high hydraulic loading during that period. The Mt. Shasta tour #1 performance reflects the frozen filters, and the Moriarty tour #1 high mean value reflects the poor initial operation and the relatively high applied suspended solids concentrations.

VOLATILE SUSPENDED SOLIDS

The statistical analysis of the mean volatile suspended solids concentrations is presented in Table 37. Seven tour means were found not to be statistically different at the 95 percent confidence level. Of the nine tours only Moriarty tour #1 and Mt. Shasta tour #1 were statistically different. The reasons for the differences are essentially the same as were discussed for the suspended solids.

TABLE 37. COMPARISON OF MEAN VOLATILE SUSPENDED SOLIDS CONCENTRATIONS USING DUNCAN'S MULTIPLE RANGE TEST[a]

Treatment	M3	MS3	A2	MS2	A1	M2	A3	M1	MS1
Mean VSS mg/l	5.0	5.3	5.8	6.1	6.8	7.1	10.3	14.1	22.8
No. of Samples	30	15	30	29	30	30	30	30	30

CODE: MS-1 Mt. Shasta - Tour #1
MS-2 Mt. Shasta - Tour #2
MS-3 Mt. Shasta - Tour #3
M-1 Moriarty - Tour #1
M-2 Moriarty - Tour #2
M-3 Moriarty - Tour #3
A-1 Ailey - Tour #1
A-2 Ailey - Tour #2
A-3 Ailey - Tour #3

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[a] Means underlined with a common line are not significantly different (95% level).

FECAL COLIFORM

Table 38 presents the statistical analysis of the tour geometric mean fecal coliform concentrations for the intermittent sand filter effluents. The tour means for the Ailey and Mt. Shasta facilities represent intermittent sand filter effluent prior to chlorination. The Moriarty tour means are for filter effluent, but with the applied wastewater chlorinated. The chlorination of the applied water effectively disinfected the lagoon effluent and the water reaching the filters was nearly bacteria free. The cause of the fecal coliform in the filter effluent was previously discussed and is unknown.

Because of the aftergrowth, one of the Moriarty tour mean fecal coliform concentrations was the highest observed followed by the first and third tour means for Mt. Shasta and the third tour at Ailey. The high values for Ailey tour #3 and Mt. Shasta tour #3 reflect the decrease in fecal coliform removal because of high hydraulic loading rates during

TABLE 38. COMPARISON OF MEAN FECAL COLIFORM CONCENTRATIONS USING DUNCAN'S MULTIPLE RANGE TEST[a]

Treatment	A2	M3	MS2	A1	M1	A3	MS3	MS1	M2
Geometric Mean	1	2	2	2	8	21	37	55	91
No. of Samples	30	30	29	30	30	30	15	30	30
Fecal Coliform Concentration Calories/ 100 ml									
							─	─	─
						─	─		
	─	─	─	─	─				

CODE: MS-1 Mt. Shasta - Tour #1
MS-2 Mt. Shasta - Tour #2
MS-3 Mt. Shasta - Tour #3
M-1 Moriarty - Tour #1
M-2 Moriarty - Tour #2
M-3 Moriarty - Tour #3
A-1 Ailey - Tour #1
A-2 Ailey - Tour #2
A-3 Ailey - Tour #3

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[a] Mean underlined with a common line are not significantly different (95% level).

these periods. High fecal coliform concentrations during tour #1 at Mt. Shasta were related to the frozen filters.

The first four ranked tour means do not vary statistically within the 95 percent confidence level. Ailey tours #1 and #2 represent the most consistent fecal coliform removal. Moriarty tour #3 low fecal coliform bacterial populations reflect filter maturity and operational stability. The inclusion of Mt. Shasta tour #2 reprsents the ability of the system to produce good fecal coliform reductions when operated properly.

Summary of Statistical Analysis

In review of the statistical analysis of the parameters it is easily observed that the effluent quality of the intermittent sand filter is not statistically different for the majority of the sampling periods at each location. The excluded tours (statistically different) consistently included one tour from each facility (Mt. Shasta tour #1, Moriarty tour #1, and Ailey tour #3). All three tours can be identified with specific operational problems. The identification and correction of these operational problems has been discussed in detail in the previous sections. It can be safely concluded that the intermittent sand filters can provide a consistently high quality effluent when designed and operated properly.

SECTION 9

EXISTING OR PLANNED INTERMITTENT SAND FILTERS USED TO UPGRADE LAGOON EFFLUENT

GENERAL DESCRIPTION

Table 39 presents a summary of the locations where intermittent sand filters are being used or constructed to upgrade lagoon system effluents. Table 39 also provides a tabulation of the basic design information, names of the consultants or designers, and the year when the facility was put into service. This summary is not a complete tabulation of intermittent sand filters used to polish lagoon effluents, but a collection of the facilities that have been in operation or are near completion of the construction phase. These facilities are located in the same states as the three sites studied with an additional one in Utah. This collection reflects the acceptance of intermittent sand filters as a means of upgrading lagoon effluent primarily in the areas where the filters have been put into use in recent years. Although many other filters have been proposed in other states, the conservative nature of state regulatory agencies has resulted in the elimination of many filter systems at various stages of design.

A tabulation of the design criteria and the economic analyses for the systems listed in Table 39 is presented in Table 40.

Capital cost estimates for the systems were derived from bid summary sheets or information provided by the design engineer or contractor. The cost per 3.8 m^3 (1 MGD) of filtrate was calculated from annual costs based on a 7 percent interest rate and a 20-year service life (Kurtz, 1959). Annual operating and maintenance costs for the three sites visited during the study were calculated using the observed maintenance and operating costs (including energy consumption) incurred over the period of the study.

Figures 81 through 93 are flow diagrams for the facilities listed in Tables 39 and 40 except for the three facilities monitored during this study. Diagrams for these three systems are presented in Figures 2 through 4. The description of the facilities provided by the combination of schematics and design criteria tables should be adequate to interpret differences between the systems.

TABLE 39. SUMMARY OF EXISTING AND/OR PLANNED INTERMITTENT SAND FILTERS USED TO UPGRADE LAGOON EFFLUENT

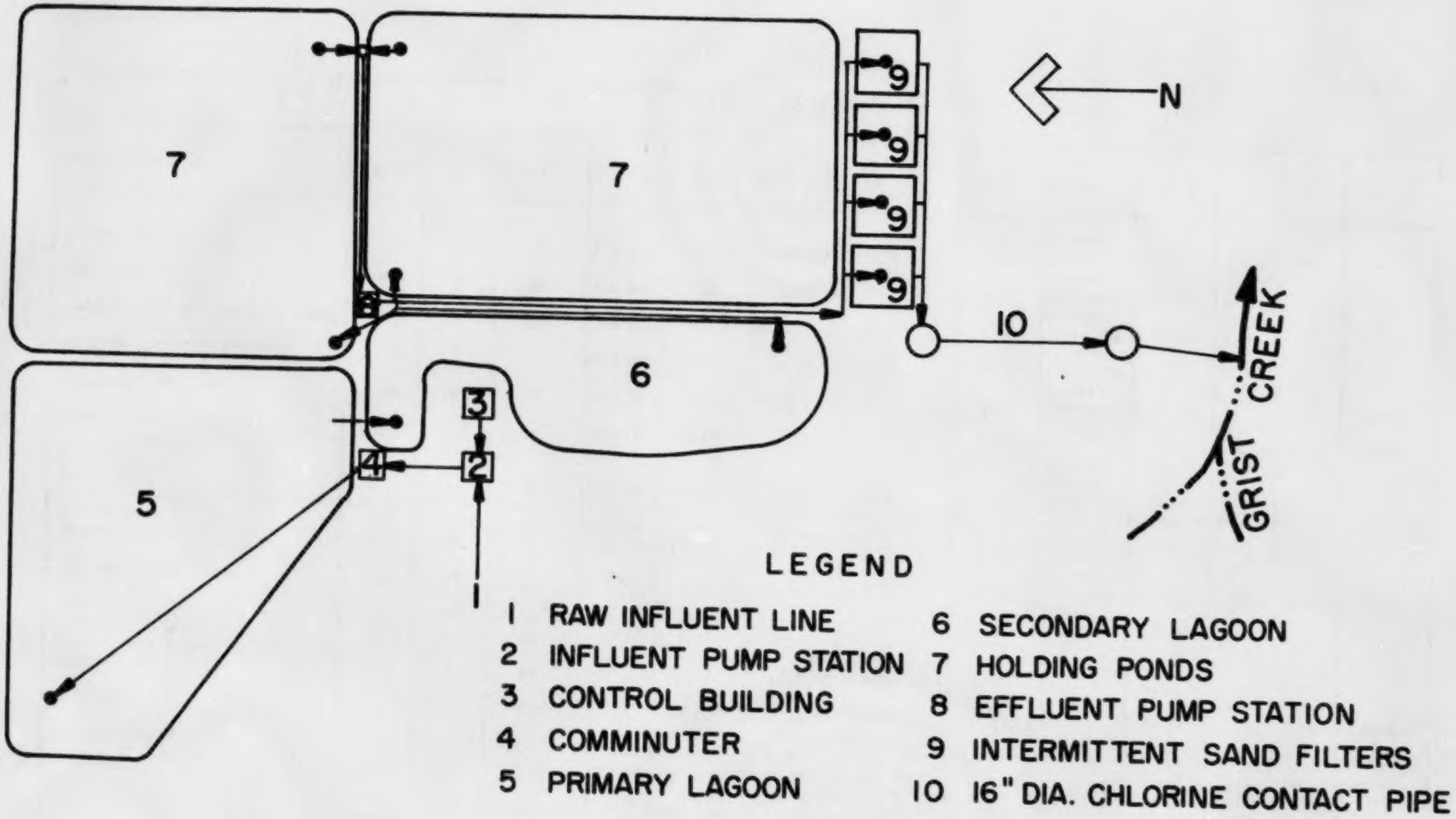
Location	Consultant or Designer	Completion Date
Covello, California	Barrett & Associates, Inc., Los Altos, California	Fall 1977
City of Mt. Shasta, California	W.A. Gelonek & Affiliates, Inc., Redding, California	Fall 1976
Tomales, California	Montgomery Consulting Engineers, Inc Walnut Creek, California	Spring 1978
Cimarron, New Mexico	Ralph E. Vail Consulting Engineer, Santa Fe, New Mexico	Fall 1975
Cuba, New Mexico	Molzen-Corbin & Associates, Albuquerque, New Mexico	Winter 1976
Moriarty, New Mexico	Molzen-Corbin & Associates, Albuquerque, New Mexico	Spring 1976
Portales, New Mexico	Ralph E. Vail Consulting Engineer, Santa Fe, New Mexico	Winter 1976
Roy, New Mexico	Ralph R. Vail Consulting Engineer, Santa Fe, New Mexico	--1976
Adel, Georgia	Thomas & Hurron Engineering Co., Savannah, Georgia	Fall 1978
Ailey, Georgia	McCrary Engineering Corp., Atlanta, Georgia	Winter 1976
Cummings, Georgia	Southern Engineering, Atlanta, Georgia	Summer 1978
Douglas County, Georgia (school)	State of Georgia	Summer 1976
Douglas County, Georgia (Nursing Home)	Tribble & Richardson, Inc., Macon, Georgia	1978
Shellman, Georgia	Tribble & Richardson, Inc., Macon, Georgia	1979
Stone Mountain, Georgia	Robert and Company Associates Atlanta, Georgia	Winter 1976
Huntington, Utah	Valley Engineering, Logan, Utah	Winter 1976

TABLE 40. SUMMARY OF DESIGN CRITERIA AND COSTS FOR EXISTING AND PROPOSED INTERMITTENT SAND FILTERS USED TO UPGRADE LAGOON EFFLUENT

Location	Design Criteria									Annual Costs $\$/m^3$ of Filtrate			
	Design Flow	Type of Lagoon[a]	Lagoon Retention Time	Filters #/Size	Hydraulic Loading Rate	Effective Size of Sand	Uniformity Coefficient	Depth of Sand	Type of Loading[a]	Filter Capital	Filter O&M	Filter Total	Year of Cost
	m^3/d		Days	#/ha	$m^3/h \cdot d$	mm		m					
Covello, Ca.	303	F	49	4/0.05	4680	0.6-0.7	N.A.	0.61	Pump & Valves	0.11	-	-	-
Mt. Shasta, Ca.	2650*L*	A	20*L*	3/0.4	6548	0.37	5.1	0.61	Auto. Valve	0.05	0.01	0.06	1976
Tomales, Ca.	144	A	29	2/0.013	5425	0.15-0.30	1.5-2.5	0.91	Pump	0.07	-	-	-
Cimarron, N.M.	568	F	55	2/0.04	7483	N.A.	N.A.	0.61	SS	-	-	-	-
Cuba, N.M.	530	A&F	20	4/0.02	5616	N.A.	N.A.	0.61	Inverted Siphon	0.05*	-	-	-
Moriarty, N.M.	757	A&F	20	8/0.03	5616	0.2	4.1	0.61	Inverted Siphon	0.03	0.01	0.04	1976
Portalles, N.M.	7571	A&F	20	3/0.40	18720	0.4	3.2	0.76	SS	-	-	-	-
Roy, N.M.	212	F	60	2/0.03	7015	0.4	3.2	0.61	SS	0.01	-	-	-
Adel, Ga.	4164	A	30	2/0.40	4680	0.25	3.4	1.22	Auto. Pump & Valves	0.02	-	-	-
Ailey, Ga	303	F	70	2/0.06	3744	0.25	3.3	0.76	Auto. Valve	0.05	0.005	0.06	1976
Cummings, Ga	757	A&F	36	4/0.06	2806	0.25-0.80	<4	0.68	Pump & Siphons	0.03	-	-	1978
Douglas Co., Ga. (school)	49	F	5	2/0.008	2806	0.30	3.67	0.76	Inverted Siphon	-	-	-	-
Douglas Co., Ga. (nursing home)	129	F	45	2/0.013	4680	0.35-0.75	<3.5	0.76	Inverted Siphon	0.04	-	-	-
Shellman, Ga.	568	F	55	4/0.032	4680	0.35-0.75	<3.5	0.91	Inverted Siphon	0.01	-	-	-
Stone Mountain, Ga.	76	F	1	1/0.081	1430	0.45-0.55	±1.5	0.76	Pump & Siphon	-	0.03	-	-
Huntington, Ut.	1136	F	214	3/0.27	1872	0.2 -0.25	<3	1.22	Manual valves	0.05	-	-	-

[a] *A* = Aerated Lagoons *F* = Facultative Lagoons *L* = Dry Weather Flow SS = Slow Sand Filter

*25% of total capital.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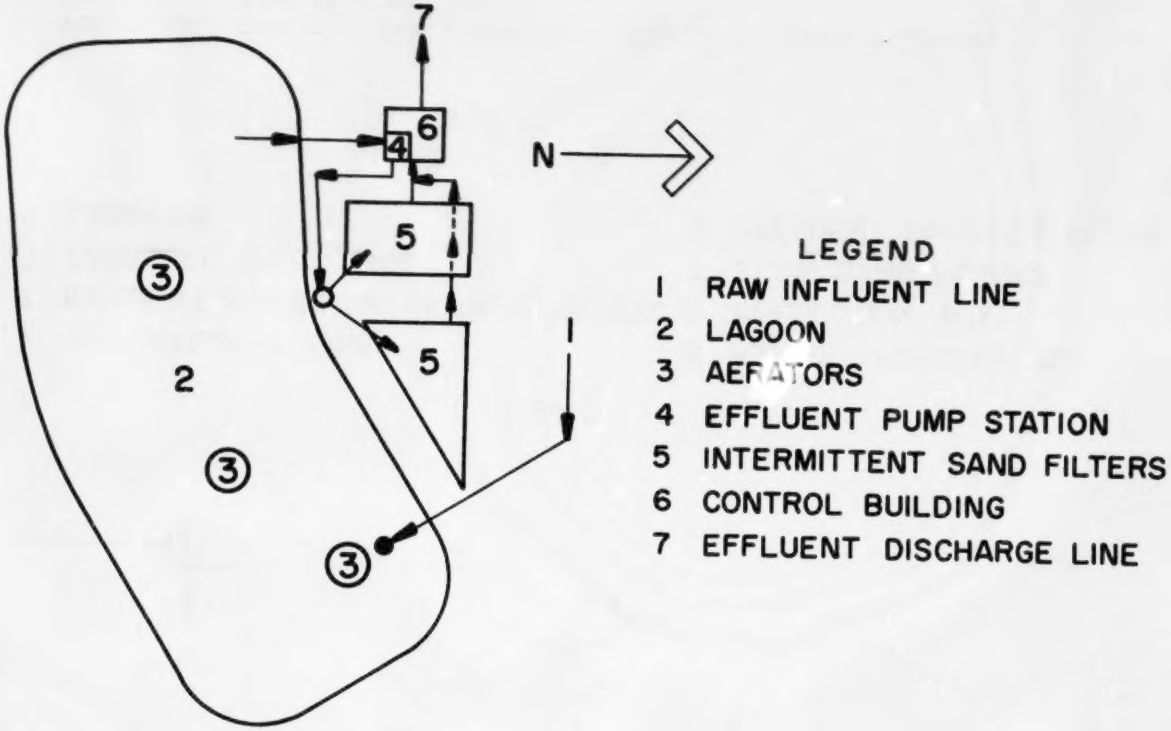
CREEK
GRIST
LEGEND
1 RAW INFLUENT LINE
2 INFLUENT PUMP STATION
3 CONTROL BUILDING
4 COMMINUTER
5 PRIMARY LAGOON
6 SECONDARY LAGOON
7 HOLDING PONDS
8 EFFLUENT PUMP STATION
9 INTERMITTENT SAND FILTERS
10 16" DIA. CHLORINE CONTACT PIPE

Figure 81. Covello, CA., wastewater treatment facility process flow diagram.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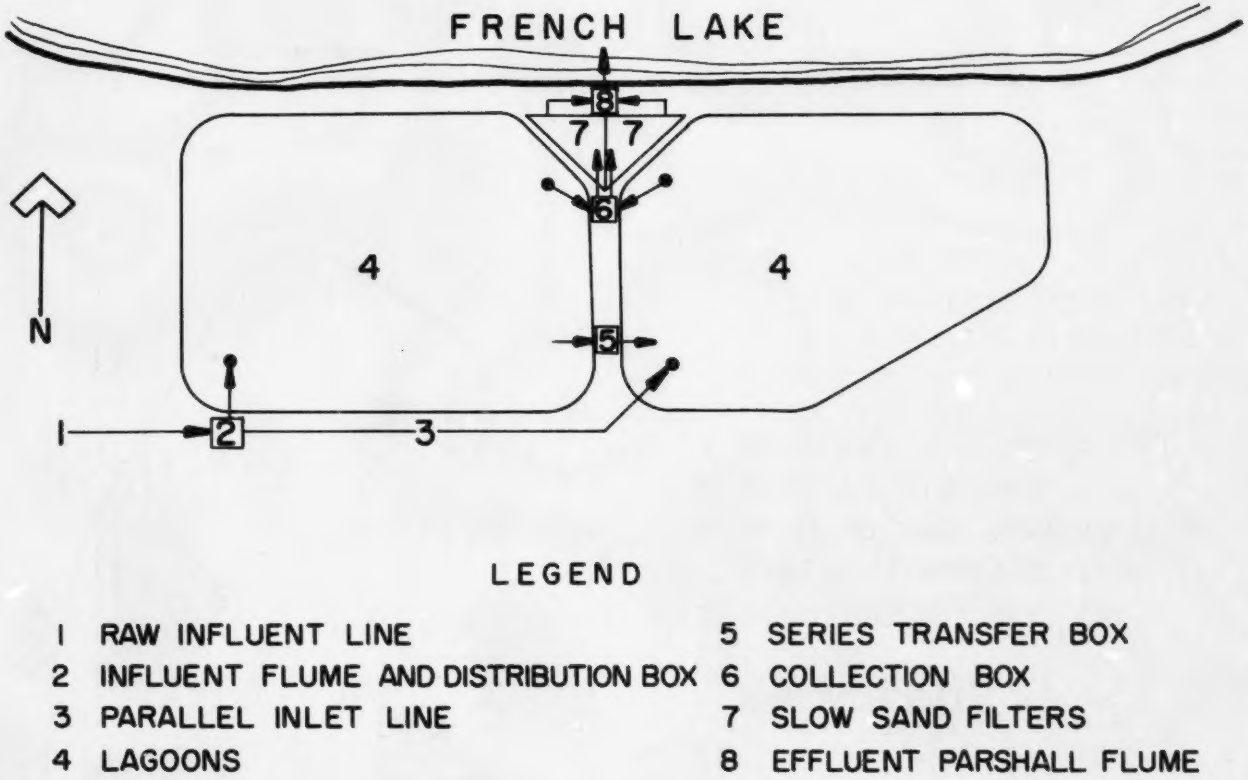
1 RAW INFLUENT LINE
2 LAGOON
3 AERATORS
4 EFFLUENT PUMP STATION
5 INTERMITTENT SAND FILTERS
6 CONTROL BUILDING
7 EFFLUENT DISCHARGE LINE

Figure 82. Tomales, CA., wastewater treatment facility process flow diagram.


FRENCH LAKE
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LEGEND
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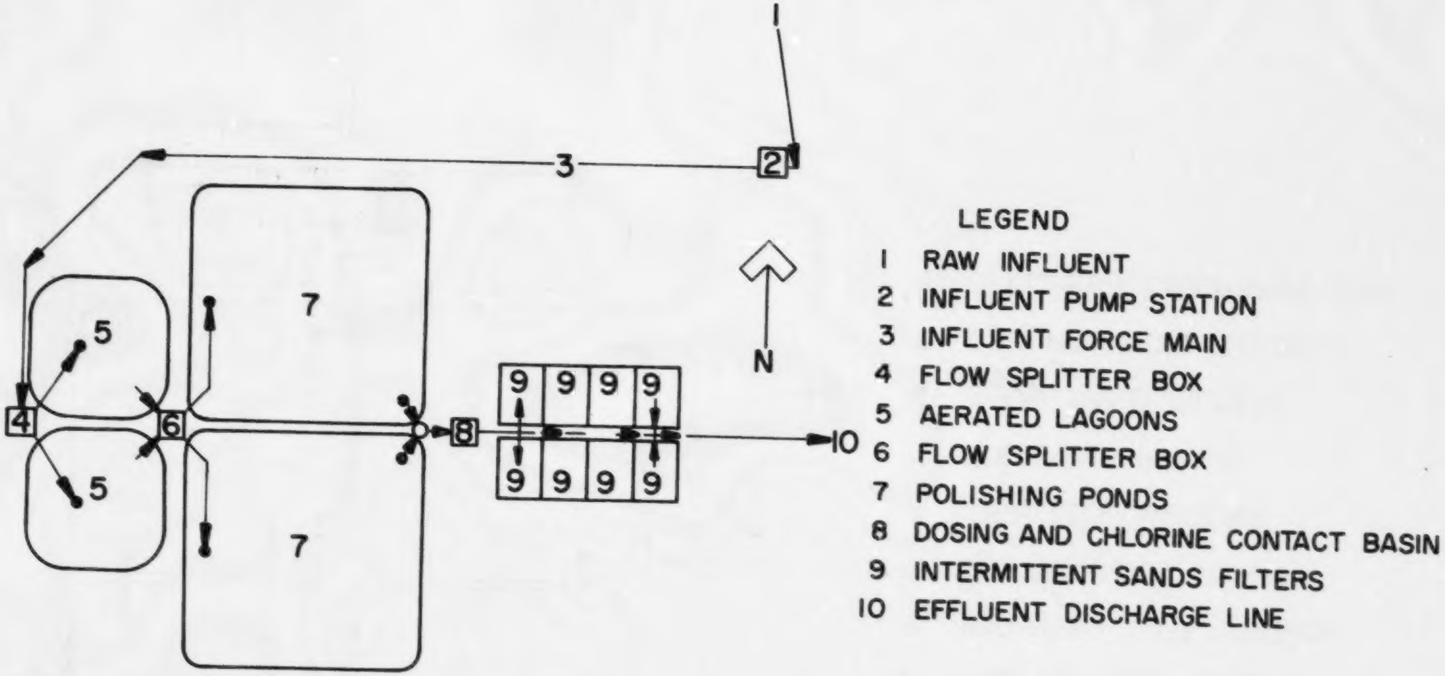
2 INFLUENT FLUME AND DISTRIBUTION BOX
3 PARALLEL INLET LINE
4 LAGOONS
5 SERIES TRANSFER BOX
6 COLLECTION BOX
7 SLOW SAND FILTERS
8 EFFLUENT PARSHALL FLUME

Figure 83. Cimarron, N.M., wastewater treatment facility process flow diagram.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LEGEND
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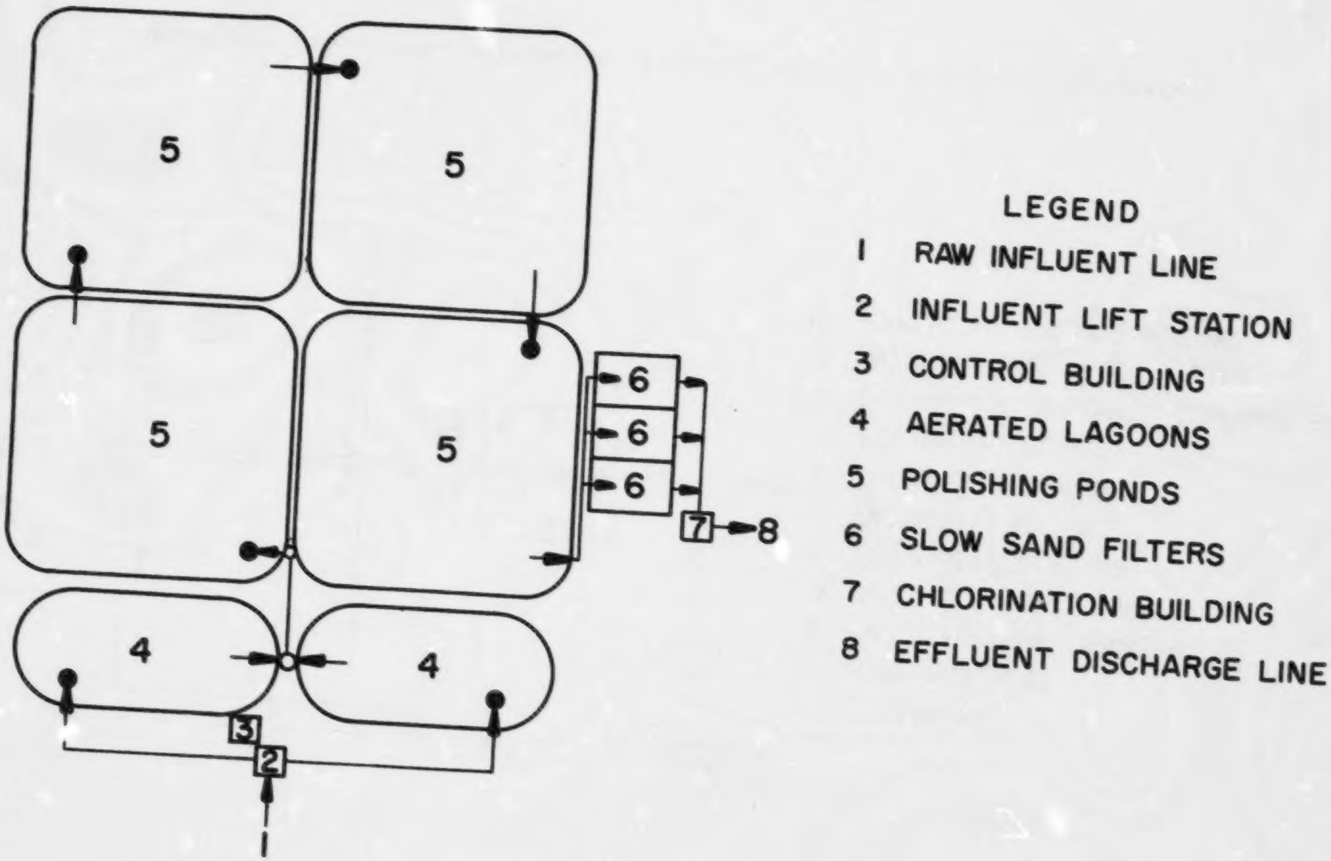
2 INFLUENT PUMP STATION
3 INFLUENT FORCE MAIN
4 FLOW SPLITTER BOX
5 AERATED LAGOONS
6 FLOW SPLITTER BOX
7 POLISHING PONDS
8 DOSING AND CHLORINE CONTACT BASIN
9 INTERMITTENT SANDS FILTERS
10 EFFLUENT DISCHARGE LINE

Figure 84. Cuba, N.M., wastewater treatment facility process flow diagram.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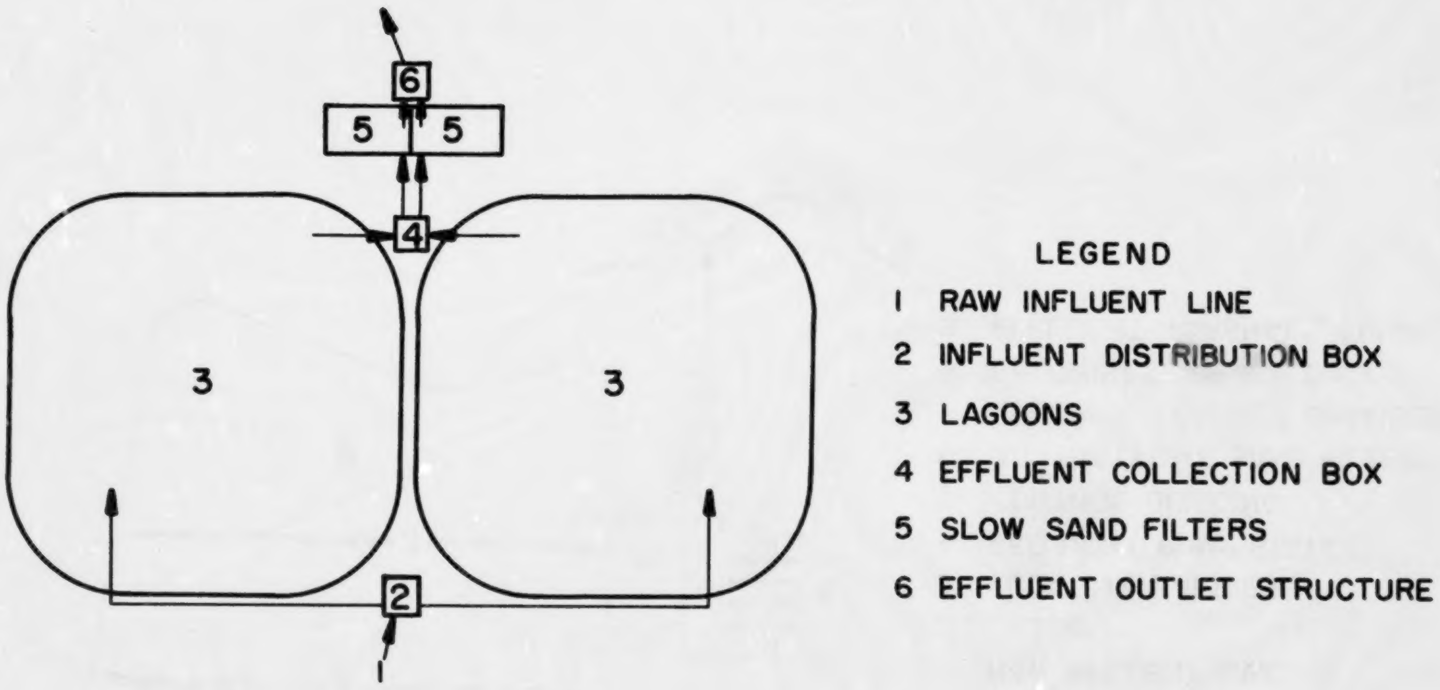
LEGEND
1 RAW INFLUENT LINE
2 INFLUENT LIFT STATION
3 CONTROL BUILDING
4 AERATED LAGOONS
5 POLISHING PONDS
6 SLOW SAND FILTERS
7 CHLORINATION BUILDING
8 EFFLUENT DISCHARGE LINE

Figure 85. Portales, N.M., wastewater treatment facility process flow diagram.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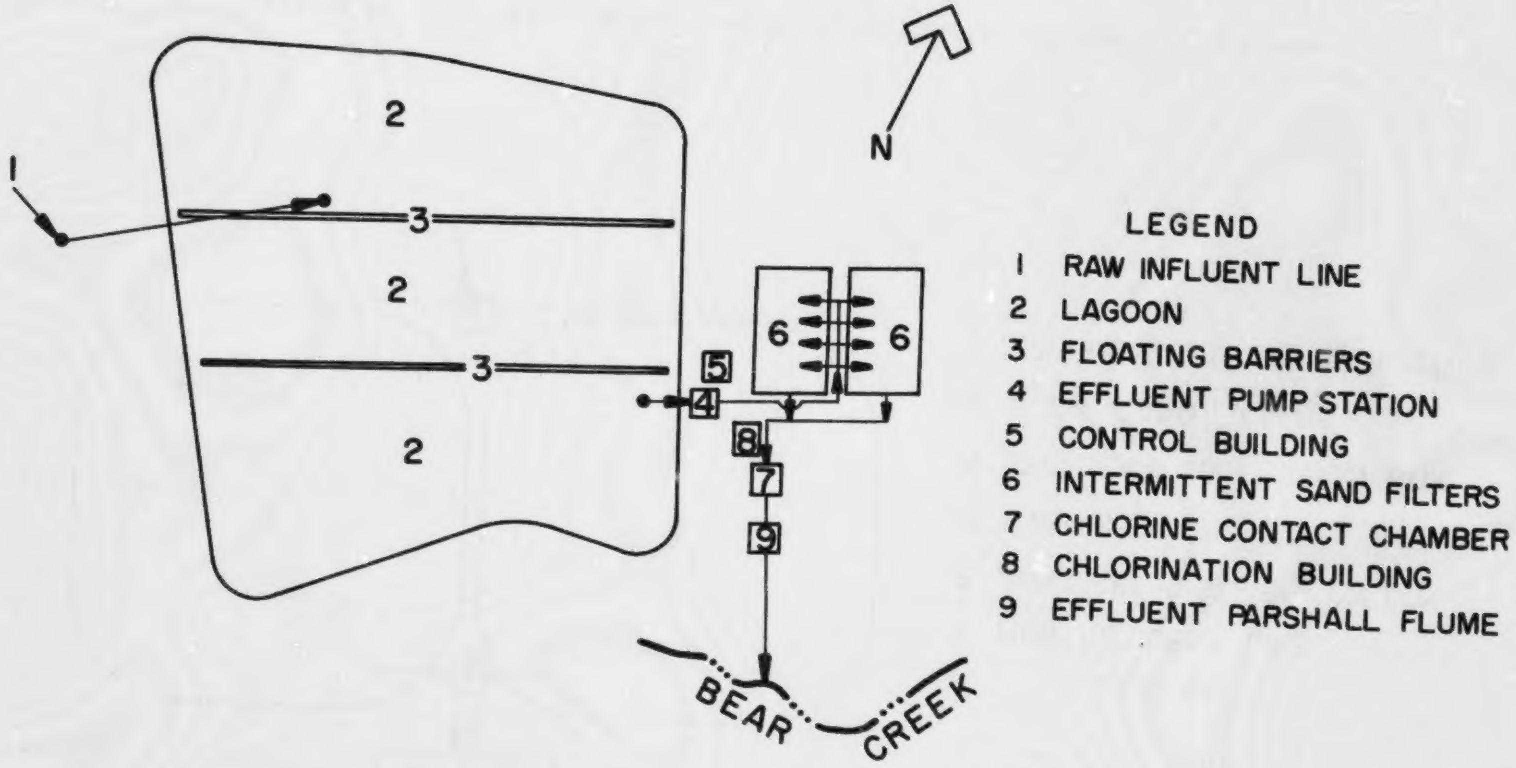
LEGEND
1 RAW INFLUENT LINE
2 INFLUENT DISTRIBUTION BOX
3 LAGOONS
4 EFFLUENT COLLECTION BOX
5 SLOW SAND FILTERS
6 EFFLUENT OUTLET STRUCTURE

Figure 86. Roy, N.M., wastewater treatment facility process flow diagram.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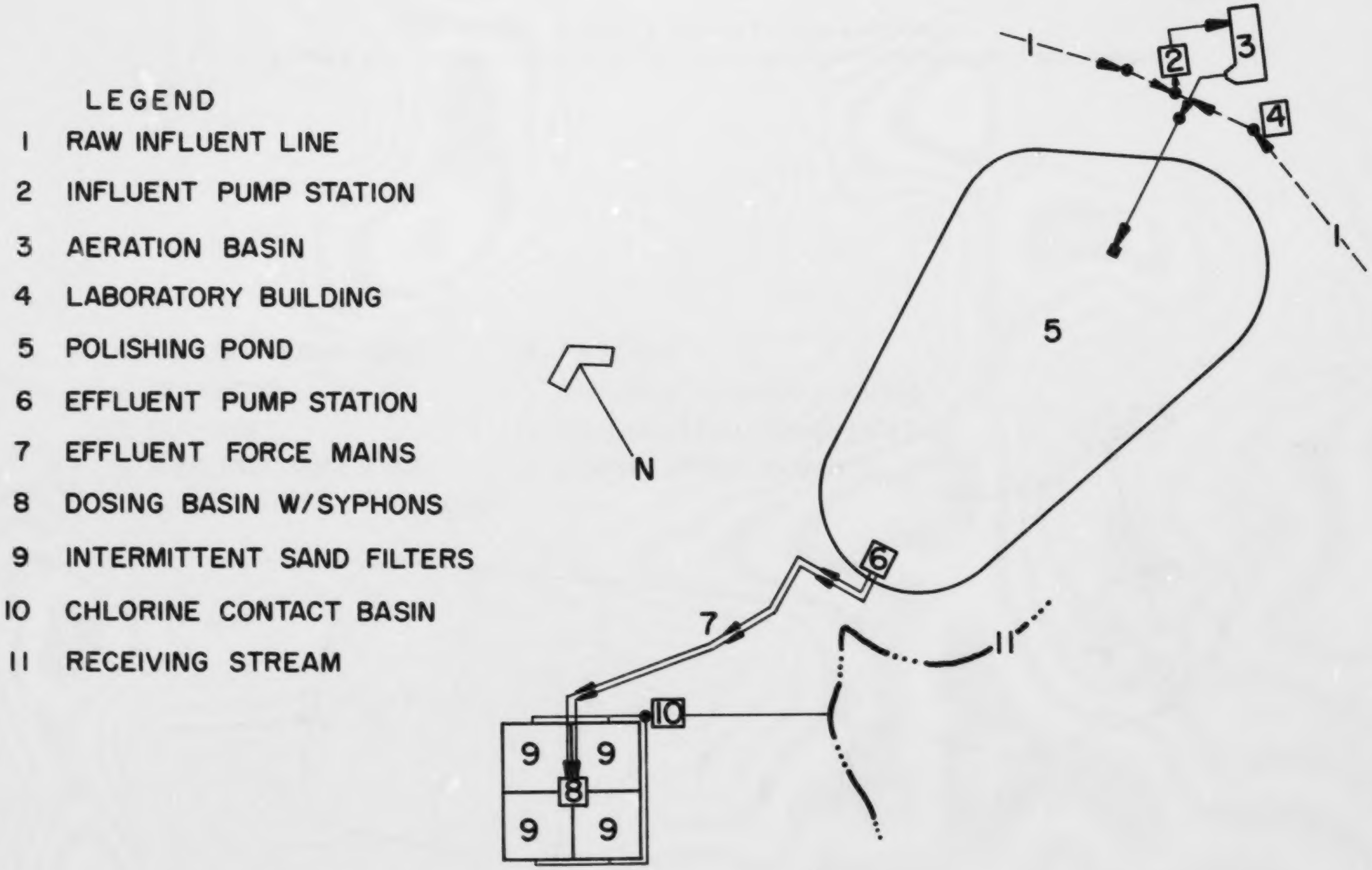
CREEK
LEGEND
1 RAW INFLUENT LINE
2 LAGOON
3 FLOATING BARRIERS
4 EFFLUENT PUMP STATION
5 CONTROL BUILDING
6 INTERMITTENT SAND FILTERS
7 CHLORINE CONTACT CHAMBER
8 CHLORINATION BUILDING
9 EFFLUENT PARSHALL FLUME

Figure 87. Adel, GA., wastewater treatment facility process flow diagram.


LEGEND
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2 INFLUENT PUMP STATION
3 AERATION BASIN
4 LABORATORY BUILDING
5 POLISHING POND
6 EFFLUENT PUMP STATION
7 EFFLUENT FORCE MAINS
8 DOSING BASIN W/SYPHONS
9 INTERMITTENT SAND FILTERS
10 CHLORINE CONTACT BASIN
11 RECEIVING STREAM
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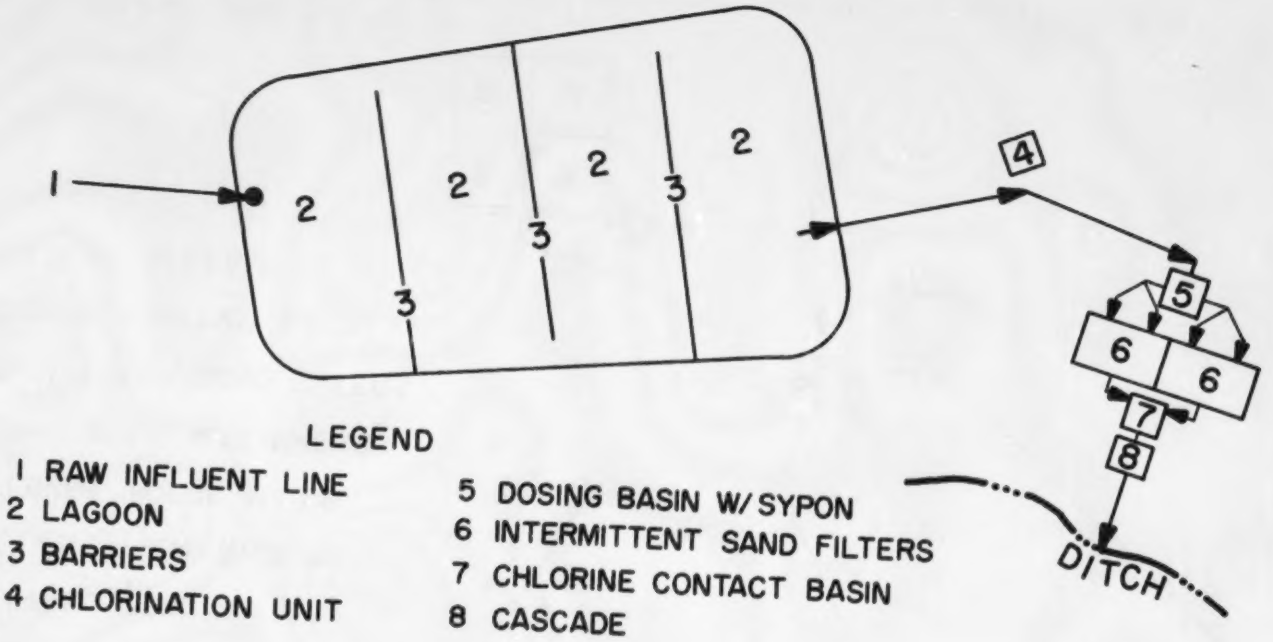
Figure 88. Cummings, GA., wastewater treatment facility process flow diagram.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DITCH
LEGEND
1 RAW INFLUENT LINE
2 LAGOON
3 BARRIERS
4 CHLORINATION UNIT
5 DOSING BASIN W/ SYPON
6 INTERMITTENT SAND FILTERS
7 CHLORINE CONTACT BASIN
8 CASCADE

Figure 89. Garden City Nursing Home, Douglas County, GA., wastewater treatment facility process flow diagram.

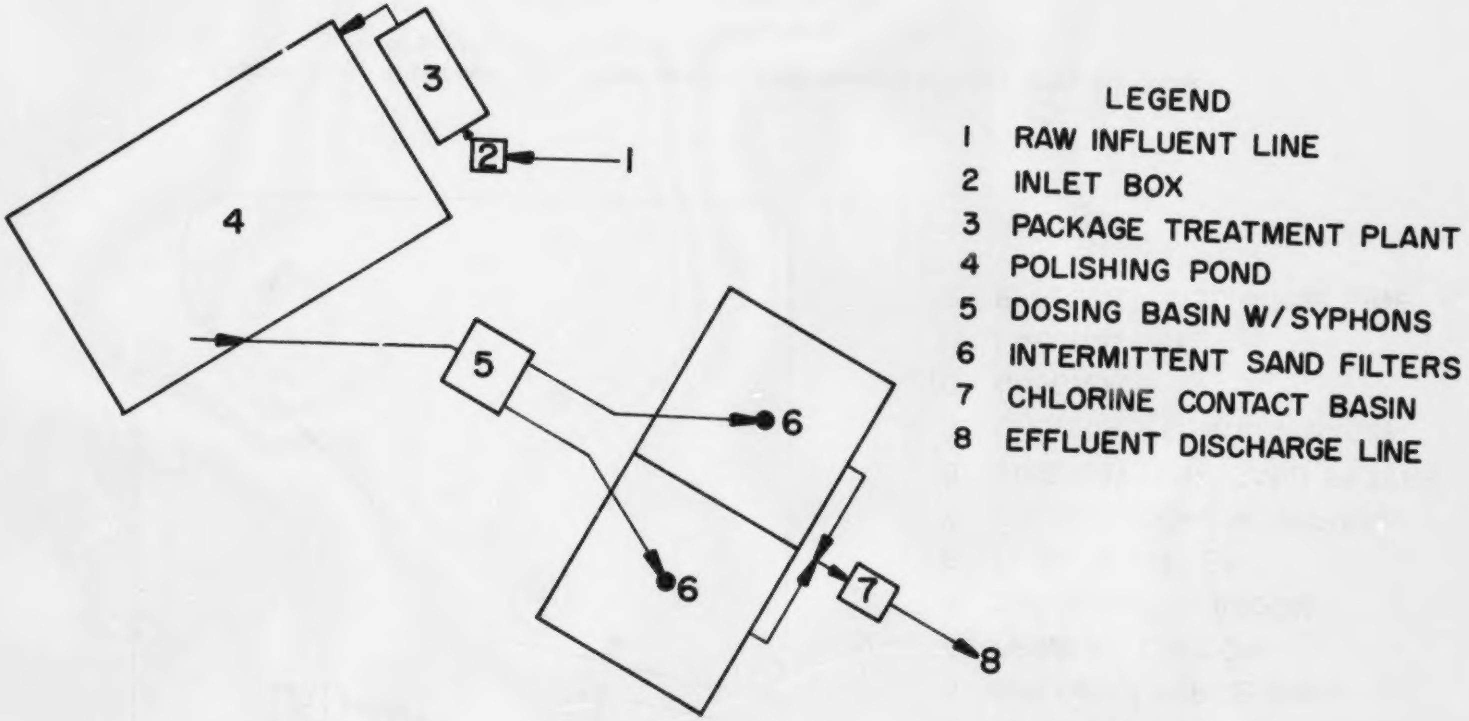
LEGEND
1 RAW INFLUENT LINE
2 INLET BOX
3 PACKAGE TREATMENT PLANT
4 POLISHING POND
5 DOSING BASIN W/SYPHONS
6 INTERMITTENT SAND FILTERS
7 CHLORINE CONTACT BASIN
8 EFFLUENT DISCHARGE LINE
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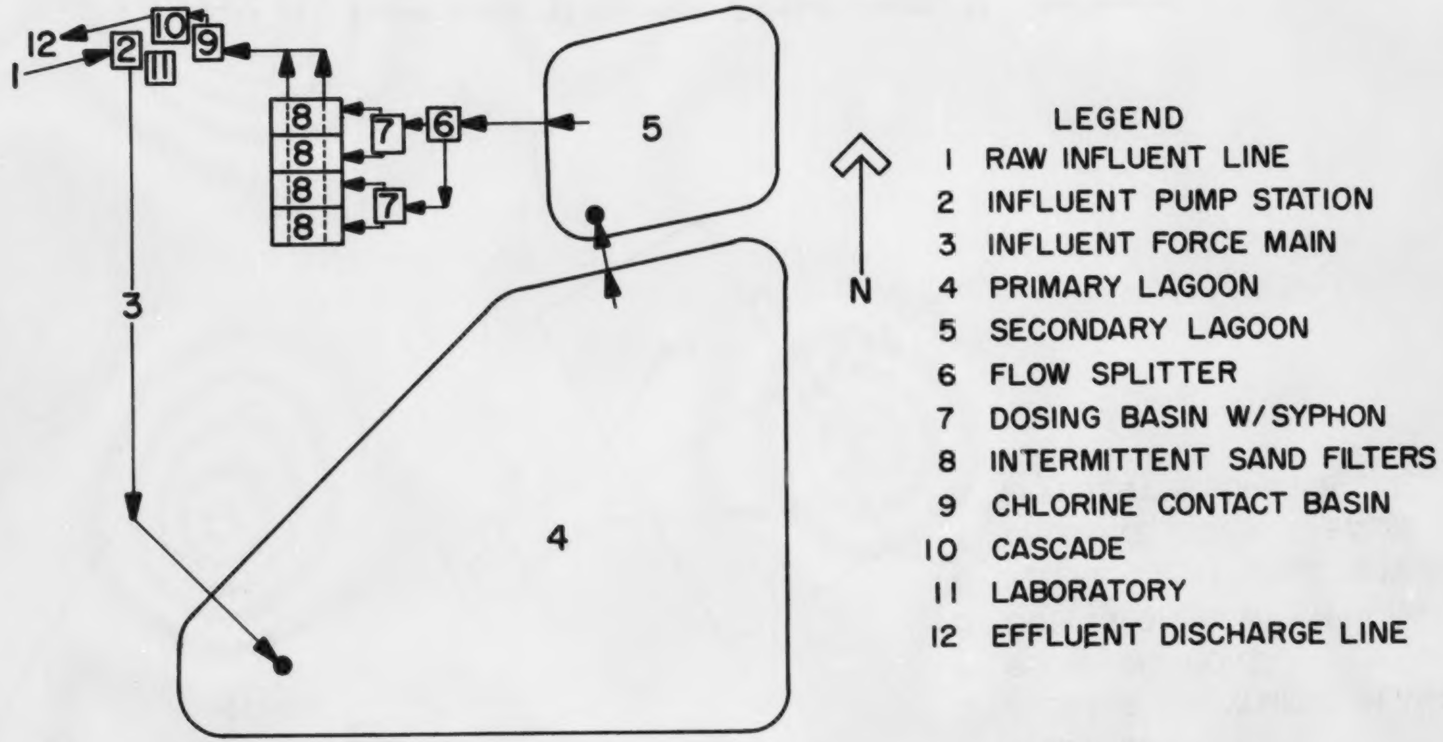
Figure 90. Turner Junior High School, Douglas County, GA., wastewater treatment facility process flow diagram.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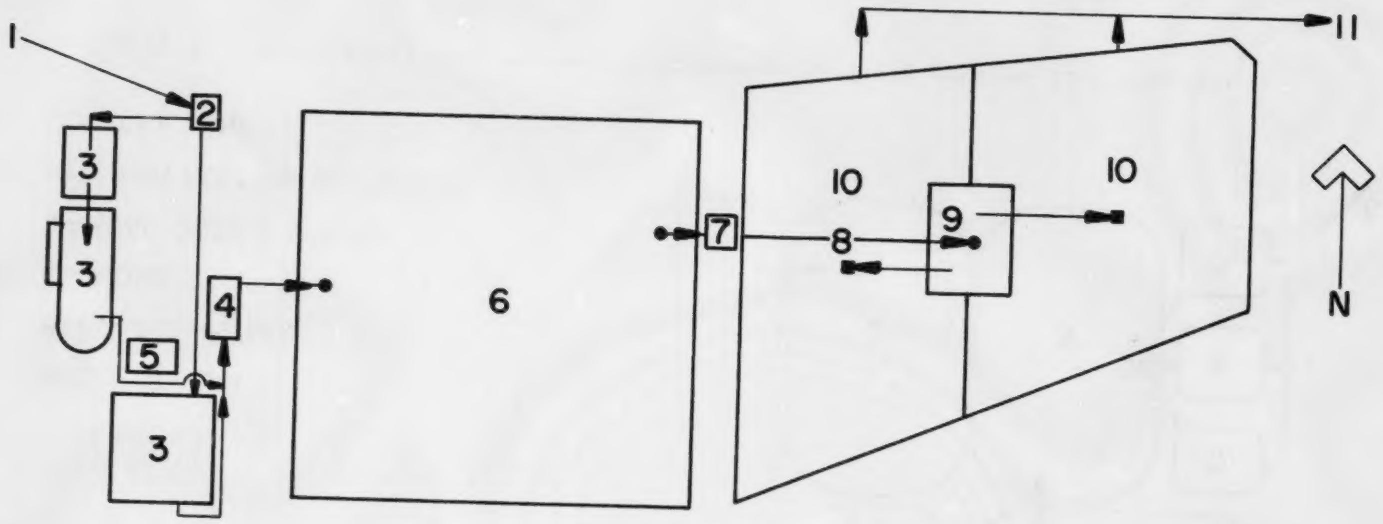
LEGEND
1 RAW INFLUENT LINE
2 INFLUENT PUMP STATION
3 INFLUENT FORCE MAIN
4 PRIMARY LAGOON
5 SECONDARY LAGOON
6 FLOW SPLITTER
7 DOSING BASIN W/SYPHON
8 INTERMITTENT SAND FILTERS
9 CHLORINE CONTACT BASIN
10 CASCADE
11 LABORATORY
12 EFFLUENT DISCHARGE LINE

Figure 91. Shellman, GA., wastewater treatment facility process flow diagram.



LEGEND

1	RAW INFLUENT LINE	7	EFFLUENT PUMP STATION
2	INFLUENT JUNCTION BOX	8	EFFLUENT FORCE MAIN
3	PACKAGE TREATMENT PLANTS	9	DOSING BASIN W/SYPHONS
4	CHLORINE DETENTION BOX	10	INTERMITTENT SAND FILTERS
5	HYPO-CHLORINATION BUILDING	11	EFFLUENT DISCHARGE LINE
6	POLISHING POND		

Figure 92. Stone Mountain Memorial Park, GA., wastewater treatment facility process flow diagram.

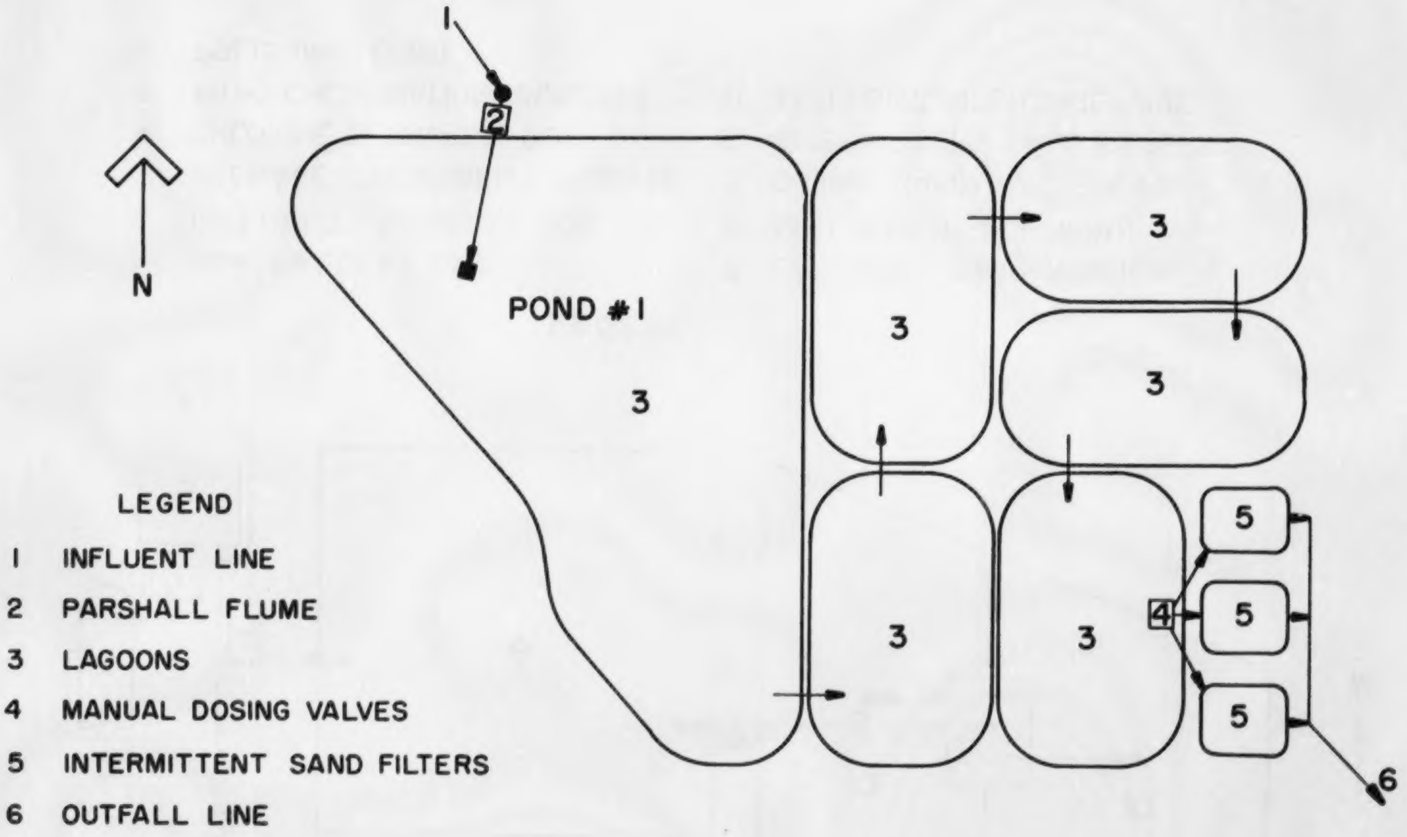

1
2
N
POND #1
3
3
3
3
3
3
4
5
5
5
6
LEGEND
1 INFLUENT LINE
2 PARSHALL FLUME
3 LAGOONS
4 MANUAL DOSING VALVES
5 INTERMITTENT SAND FILTERS
6 OUTFALL LINE

Figure 93. Huntington, UT., wastewater treatment facility process flow diagram.

OPERATION AND MAINTENANCE

The operation and maintenance data for existing intermittent sand filters used to upgrade lagoon effluent was restricted to the three systems evaluated during this study and the system located at Stone Mountain, Georgia. Additional operating and maintenance data beyond that obtained at the three sites during this study were not obtained because the other facilities were not operating or did not maintain adequate records for analysis. Requests were made for operating facilities to maintain records, but what was provided was inadequate. Also the lack of any maintenance or operation made an analysis impossible.

RELATED OPERATIONAL AND MAINTENANCE INFORMATION

Two cities in western Oregon use slow sand filtration of river water to produce the municipal water supply with wells for backup. The maintenance of the slow sand filter is essentially the same as that used for intermittent sand filters. Only the nature of the filtered material differs, with the slow sand filter removing primarily inorganic matter and the intermittent sand filters removing organic matter.

Because of the similarity in the maintenance of the two systems and the unique approach used by these two cities to minimize maintenance costs and prolong the filter service life, operating experiences and manpower requirements were obtained. Also this information applies to large sand filters that might use mechanical cleaning devices.

Table 41 presents the information regarding the operating and maintenance requirements for the slow sand filter systems at Stayton and Salem, Oregon.

SUMMARY

Annual capital costs for the intermittent sand filters ranged from \$0.01 to \$0.11 per m^3 of filtrate. Some of the higher costs reflect the use of pumps to load the filters, but variations between areas of the country and local sand costs are also reflected. The annual cost of the filters represented from 7 to 38 percent of the total annual cost for the complete lagoon-filter systems. The average was less than 25 percent.

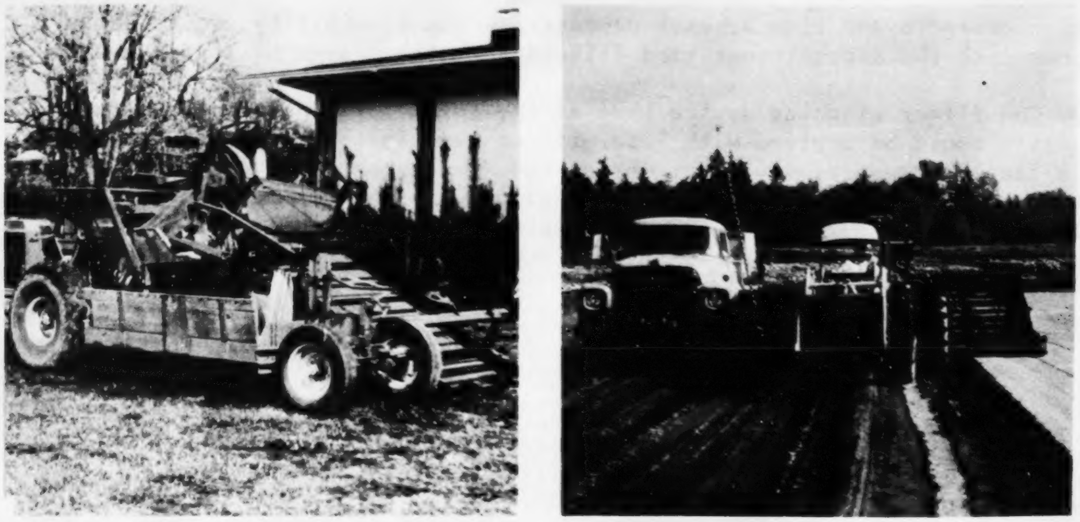
The operation and maintenance costs for the three selected sites demonstrated the relatively small cost for the treatment provided by the intermittent sand filters. The Moriarty and Mt. Shasta facilities both operated for \$0.01 per m^3 of filtrate, and the Ailey, Georgia, system cost the least to operate at \$0.005 per m^3 of filtrate because of the long filter run times and the low labor costs in the southeastern section of the USA.

Total annual costs for the three filters evaluated in this study ranged from \$0.04 to \$0.06 per m^3 of filtrate. These costs are well below the costs of other alternate lagoon upgrading techniques. The variations in

TABLE 41. SUMMARY OF OPERATING AND MAINTENANCE EXPERIENCES FOR THE SLOW SAND FILTERS AT STAYTON AND SALEM, OREGON

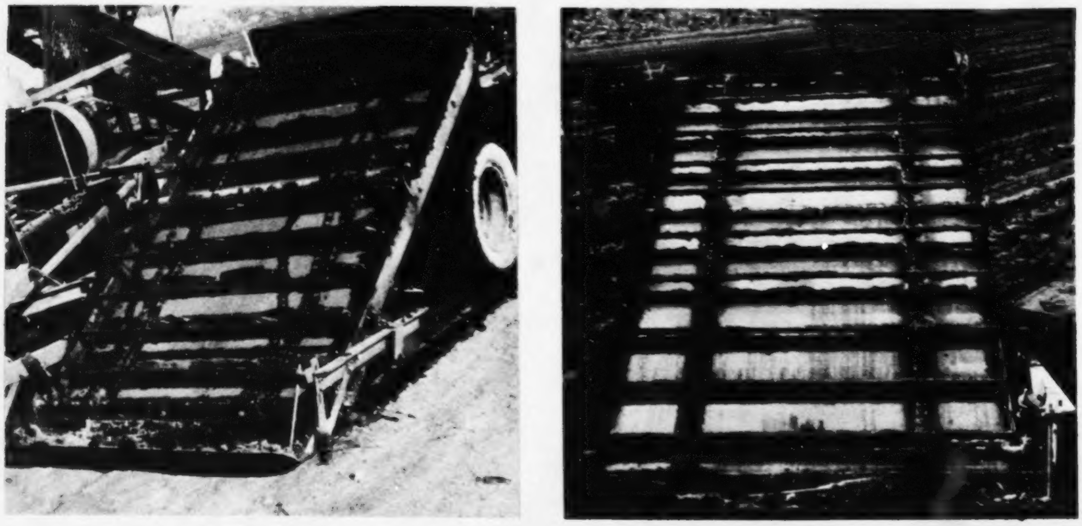
Topic	Location	
	Salem, Oregon	Stayton, Oregon
Number of Filters	2	2
Individual Filter Size	2.02 hectare	0.4 hectare
Design Capacity per Filter	189,250 m^3/day	9462 m^3/day
Design Hydraulic Loading	93,688 m^3/ha·d	23,655 m^3/ha·d
Normal Hydraulic Loading	Winter - 37,475 m^3/ha·d Summer - 112,425 m^3/ha·d	Winter - N.A. Summer - 18,718 m^3/ha·d
Depth of Sand	0.91 m	0.91 m
Average Number of Cleanings/yr	2	5
Amount of Sand Removed/ Cleaning	0.6 to 1.2 cm	0.6 to 1.2 cm
Time Requirements for Cleaning a Filter	4-6 hours (1 person)	2 days (2 persons)
Equipment Used	Self-Propelled Cleaning Unit*	Tractor Pulled Cleaning Unit* 1 truck 1 scarifier 1 floating device
Comments	Cleaning of the filters normally takes place in the Spring when high turbidity is prevalent.	Cleaning takes place normally every 2-2½ months and every 6 weeks during peak flow (Summer)

*Filter cleaning device was first built by the Salem operator from a grain combine. The Stayton version is a self-propelled copy with different disposal techniques (see Figure 94).



Self-Propelled Unit at Stayton, Oregon

Cleaning Operation at Salem, Oregon



Close Up of Cleaning Operation at Salem, Oregon

Front View of Scraping Device at Salem, Oregon

Figure 94. Photographs of filter sand removal devices used at Stayton and Salem, Oregon.

design criteria and flow schemes demonstrate the flexibility available to incorporate the intermittent sand filters into the design of lagoon systems.

The filter cleaning device used at the Salem, Oregon, water treatment facility could be applied with intermittent sand filters treating wastewater from larger communities without losing the advantages of low cost. The low capital costs associated with the device plus the ability to remove only 0.6 cm of media per cleaning can extend the service life of a filter considerably, and considerable savings could be realized over a period of operation.

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SECTION 10

INTERMITTENT SAND FILTER DESIGN, CONSTRUCTION AND OPERATION

GENERAL

Based upon the results of measurements made at three existing lagoon-intermittent sand filter facilities and the results of the previous studies at Utah State University, a recommended design for an intermittent sand filter has been developed. The ability of the typical design to satisfactorily meet the 1972 federal secondary treatment standards was considered when establishing the design criteria. Recommended design criteria are summarized in Table 42. These criteria are used in the typical design calculations presented in Appendix C.

The specific construction and operation of the typical intermittent sand filters are representative of northern Utah with reference to options that may be more suitable to individual and regional requirements.

Two intermittent sand filters at any one facility is a minimum requirement in order to provide an alternate filter during drying and cleaning operations. The second filter also serves as a back-up unit to provide additional capacity during possible high discharge periods. For additional flexibility in the wastewater facility the provision of four intermittent sand filters is advised.

CONSTRUCTION

Retaining Structure and Filter Bed

The most desirable topographic and locational configuration would allow for gravity flow from the lagoon system through the intermittent sand filters and disinfection system. A minimum head of 2.5 meters (bottom of underdrain to top of freeboard) would be required for gravity flow through the filters. If this minimum is not available, pumping would be required.

Metcalf and Eddy (1935) and Steel (1960) suggested that intermittent sand filters not exceed one acre but be large enough to accommodate mechanical equipment in maintenance operations. The observation of slow sand filter operations and successful and economical mechanical cleaning methods at the Salem, Oregon, Municipal Water Supply indicates that the one acre size limit is flexible.

TABLE 42. SUMMARY OF INTERMITTENT SAND FILTER DESIGN CRITERIA

Design Topic	Typical Description
Hydraulic Loading Rate	Equal to or less than 4680 $m^3/ha \cdot d$ using two or more equal dosings per day.
Filter Size & Number	Minimum of two filter units. Area of individual filters $\leq$ 0.405 ha.
Filter Shape	Dependent upon site plan and topography with rectangular shape desirable to improve distribution of wastewater.
Depth of Filter Media	Large gravel-minimum cover of 10.2 cm (leveled), medium gravel - 10.2 cm, pea gravel - 10.2 cm, filter sand - 61 to 91 cm.
Size of Filter Media and Underdrain Media	Large gravel (avg. dia. = 3.3 cm) medium gravel (avg. dia. = 1.9 cm) pea gravel (avg. dia. = 0.6 cm) sand (0.17 mm to 0.30 mm, e.s., U.C. < 10).
Filter Containment	Compacted earthen bank or reinforced concrete (free board $\geq$ 45 cm).
Influent Distribution	Dosing basin with siphon or electrically actuated valves with timer control and piping to gravel splash pads. Splash pad gravel should be 3.8 to 7.5 cm in diameter and surface area and depth should be 1 m^2 and 0.3 m, respectively.
Underdrain System	Network of clay tile or perforated PVC pipe at a slope of 0.025 percent serve as laterals. Pipes are placed in sloped ditches and attached to larger drain manifolds. Minimum lateral size is 15 cm in diameter and manifold should be adequate to transport design flowrate at a velocity of 0.91 to 1.22 m/sec when flowing full. Maximum spacing of laterals is 4.5 m.
Maintenance Considerations	Grass encroachment, rodent activity, serviceability, access to filter by cleaning devices.
Maintenance Required	Removal of vegetation on filter surface. Raking and cleaning of top layer (2-5 cm) of filter sand when plugged.
Cleaning Frequency	Dependent on hydraulic loading rate and the suspended solids concentration in the applied water (1 month to > 1 year).
Method of Cleaning	Raking maximizes the efficiency of the cleaning by fully utilizing the top layer of sand. Manual or mechanical equipment cleaning can be used.

Although rectangular shapes are most commonly used for convenience and ease of distribution system design, minimal scouring of the filter surface is one of the principal design considerations. This can be accomplished by providing several distribution outlets along the long side of a rectangle.

Containment of the filter media and the applied water can be achieved by either compacted earthen embankments with concrete or other types of retainment of the embankments and reinforced concrete walls. Methods available to line lagoons or filters are discussed at great length by Kays (1977) and Middlebrooks et al. (1978b). Sufficient compaction (85-95 percent) of an impervious material will provide a stable structure to eliminate infiltration and exfiltration of water and erosion can be controlled by various soil stabilization techniques. Aside from the use of concrete and asphaltic concrete, the availability of soil amendments and even synthetic liners have proven to be effective along with combinations of the options.

The embankments should be wide enough to handle a maintenance vehicle, and an access ramp into the filters should be provided if mechanical equipment is to be used in maintenance of the filters. A width of 2.4 m (eight feet) is the minimum for the top of embankments and ramps. The interior slope of the embankment should be between 3:1 and 6:1 with the options of bank stabilization previously discussed used for erosion and vegetation control. If exterior slopes are required, a slope not exceeding 3:1 should be used and a less expensive soil stabilization measure used such as grass or some type of vegetation. In extreme situations a slope of 2:1 can be used but must be protected against erosion and traffic.

The use of concrete retaining structures have been used successfully. In some cases construction is simpler and easy access to the filters for maintenance purposes can be provided by reinforced concrete retaining walls. Another advantage is the elimination of soil stabilization requirements and vegetation encroachment into the filter media.

Filter Underdrain System

Collection of the filtered water is achieved by a network of a main collection line(s) with lateral collection pipes spaced approximately 4.6 m (15 feet) on centers with all pipes at a slight grade of 0.025 percent to provide a flowrate of 0.91 m/sec (3 ft/s) to 1.2 m/sec (4 ft/s). The collection pipe system should be either clay tile or PVC perforated pipe. The sloping pipe network should be laid out in ditches with gentle slopes to provide adequate drainage for all sections of the filter.

Depending upon the local soil conditions, the use of a synthetic liner in the filter bottom to prevent exfiltration and infiltration may be necessary.

Filter Media

The supporting medium starts with washed large gravel, broken stone or blast furnace slag with a maximum diameter of 3.3 cm (1.5 inch) carefully placed around the underdrain network up to 10.2 cm (4 inches) above the highest pipe in the collection system. The surface of this first layer should be level to provide a base for the remaining media layers so that uniform media depths will be obtained. The next layer of rock should be made of stone with a maximum diameter of 1.9 cm and a depth of 10.2 cm. The last or top layer should consist of 0.6 cm maximum diameter rock also 10.2 cm deep.

With a properly designed underdrain a relatively unrestricted flow into the collection system is obtained. This reservoir can be utilized to control effluent discharge rates provided the water level does not reach the sand layer. In cold climates it is imperative that water levels be maintained well below the surface of the sand to avoid freezing.

To obtain the best overall performance, a sand with an effective size of approximately 0.2 mm should be used. The economics of available sand have to be considered in the design, and the trade offs of using a sand source of less desirable characteristics but with easier access should be evaluated. An effective size of 0.35 mm should not be exceeded.

The depth of the sand media should be at least 61 cm to provide adequate performance with the ability to withstand two cleaning operations (assuming 5.1 cm layer removal per cleaning operation) prior to reaching the minimum of 51 cm for effective treatment. The option of initially placing up to 91 cm of sand media is again a trade off in relation to the additional construction cost to handle the extra sand depths along with the extra sand cost and the cost of more frequent replacement operations. In general it is more desirable to use initial sand depths of 91 cm.

Influent Distribution System

The obvious first choice to deliver the influent to the filter surface is with gravity flow. Automatic operation is another important consideration and is commonly accomplished with flow activated valves, dosing siphons or timer controlled valves. Using fully automatic dosing systems is highly recommended and has the positive effect of preventing overloading of the filters.

It is suggested that a dosing siphon or electronic actuated valve be used in conjunction with a dosing basin and distribution network. The dosing siphon with proper bypass pipes and valves is generally the most economical automatic dosing system, but electronic float actuated valves with manual override mechanisms are also very effective. These two types of dosing devices require minimal elevation differentials between lagoon water level and filter surface. If an insufficient elevation differential exists, the use of pumps will be necessary.

A simple gravel splash pad at each pipe outlet is adequate for distribution systems with small head differentials. Scouring can occur if exit velocities are too great, but scouring can be controlled by using an energy dissipation ring or wall as part of the discharge structure. The overall distribution system should not be complex. The use of complex distribution devices should be kept to a minimum to enhance flexibility and minimize maintenance difficulties.

OPERATION OF INTERMITTENT SAND FILTERS

Hydraulic Loading Rate

The design hydraulic loading rates used at the three sites evaluated in this study varied from 3742 $m^3/ha \cdot d$ to 6548 $m^3/ha \cdot d$. All three systems demonstrated the ability to meet the 1972 federal secondary discharge standards regardless of hydraulic loading rates. Previous studies (Marshall and Middlebrooks, 1974; Harris et al., 1975; Reynolds et al., 1974) performed at Utah State University showed that hydraulic loading rates slightly affected the efficiency of the filters. Hydraulic loading rates equal to or less than 4680 $m^3/ha \cdot d$ were preferred principally because of the longer periods of time between cleanings.

A loading sequence using two equal dosings a day per filter to be delivered by an automatic dosing device is recommended. Using the available filters on an alternating basis with rest periods between doses effectively reduces the hydraulic loading rate. This can be accomplished using electronic timers to control the application of wastewater to the filters.

Under this operating scheme, the controlling factor becomes the lagoon system discharge flow rate. The lagoon system flow rate can be controlled to avoid major fluctuations from seasonal and climatic variations at a particular site. The option of including a lagoon level controlling device ensures control of the lagoon effluent flow rate which in turn will control filter loading rates for those periods of high flow rates.

Maintenance

The filter media and the filtered matter provide an excellent environment for weeds and grass to grow. Weed control during the growing season is achieved by complete weed removal using manual labor or with mechanical raking devices. The best method of weed control is continuous monitoring and removal of early growth.

Winter operations are basically the same as the summer except that cleaning of the filters during the winter is far more difficult. The cold season should be started with clean filters and in most instances the filters will operate through the cold weather without a cleaning being required. The system must be designed to prevent the accumulation of water in the filter underdrain to a depth near the media surface where freezing can occur.

When a filter is observed to be plugged or approaching plugged conditions, it is necessary to rejuvenate the filter surface. Two approaches are available. The first method consists of raking the media surface and breaking the surface mat of filtered matter. Raking makes the cleaning process more economical by obtaining optimum use of the media surface prior to removal. Raking can be accomplished manually with a garden rake or with a tractor and a landscape rake. A maximum of two rakings before cleaning is recommended.

When the raking process no longer rejuvenates the filter surface due to the accumulation of the filtered matter in the top layer of the media, removal of the solids laden layer is necessary. The removal process can be performed manually or with mechanical devices. A four-wheel drive garden size tractor equipped with a hydraulically operated scraper, bucket loading device and either flotation type tires or dual rear tires work well.

The spent filter sand disposal or reuse is largely dependent on the local availability of the filter sand. When sand costs are high, the removed sand should be stockpiled, washed and recycled. Storage of the sand in layers approximately 30 cm in depth and washing with 20 or more cm of clean water has successfully refurbished used sand on an experimental basis (Elliot et al., 1976). Consideration of this approach appears particularly attractive in wet climates. It is also possible that filter effluent could be used to clean the sand by this technique. Investigations should be conducted to evaluate these alternatives after the system is placed in operation.

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APPENDIX A

DATA (DAILY AND AVERAGES) FOR ALL PARAMETERS MEASURED AT ALL SAMPLING POINTS FOR THE THREE WASTEWATER TREATMENT SYSTEMS

NOTES

(field) refers to analyses performed at the sites by the field crew.

(UWRL) refers to analyses performed on preserved samples shipped by "priority mail" to the Utah Water Research Laboratory.

Mt. Shasta Tour #1 - Tables A-1 through A-8
Mt. Shasta Tour #2 - Tables A-9 through A-18
Mt. Shasta Tour #3 - Tables A-19 through A-26

Moriarity Tour #1 - Tables A-27 through A-34
Moriarity Tour #2 - Tables A-35 through A-42
Moriarity Tour #3 - Tables A-43 through A-50

Ailey Tour #1 - Tables A-51 through A-58
Ailey Tour #2 - Tables A-59 through A-66
Ailey Tour #3 - Tables A-67 through A-74

TABLE A-1. SUMMARY DATA SHEET, MT. SHASTA, #1 LAGOON INFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C	Daily Total Flow mgd
Jan. 22	53	49	85	87	29	2.5×10^6	5.8	7.7	7.1	7.6	8.5	0.605
23	74	64	82	103	31^a	4.3×10^5	5.1	7.1	6.8	7.1	9.5	0.589
24	71	36	87	188	40^a	2.8×10^5	5.4	7.2	6.1	7.2	9.0	0.580
25	80	76	82	132	36^a	5×10^5	4.9	6.7	5.8	6.8	10.0	0.552
26	72	62	83	106	36^a	5×10^5	5.8	7.3	5.6	7.1	9.0	0.528
27	90	67	89	93	35	3.6×10^6	6.4	6.9	5.8	7.0	9.0	0.532
28	89	69	83	101	38	9×10^5	5.9	7.0	5.4	7.1	10.0	0.558
29	76	66	79	110	34	$4.4 \times 10^{5\,b}$	6.2	7.1	6.6	7.0	9.0	0.580
30	81	79	89	101	32	4.3×10^6	5.0	7.1	5.9	7.1	9.0	0.566
31^c	97	84	101	144	47	7.5×10^4	N.S.	N.S.	5.1	7.2	10.0	0.572
Feb. 1	63	53	89	124	48	1.7×10^5	4.8	7.1	5.6	7.2	9.5	0.550
2	117	96	83	146/98	43/39	8.3×10^5	5.3	7.1	5.8	7.0	9.5	0.576
3	105	87	91	114	35^a	2×10^6	4.5	7.2	5.5	7.1	9.0	0.556
4	75	71	86	94	48^a	8×10^5	4.5	7.0	5.1	7.2	9.5	0.550
5	58	44	86	80	34	1.9×10^6	5.1	7.1	6.3	7.0	9.0	0.566
6	85	83	82	80	28	3.75×10^5	4.1	7.0	4.9	7.1	9.8	0.564
7	150	139	85	138	43^a	3.1×10^5	4.8	7.1	5.1	7.0	10.0	0.571
8	N.S.	N.S.	N.S	N.S.	N.S.	2.1×10^5	N.S.	N.S.	5.8	6.7	11.0	0.756
9	43	38	78	142^a	35	1.2×10^5	5.5	6.9	6.1	7.0	10.0	0.645
10	60	51	80	96	27	1.5×10^5	5.3	7.0	5.4	6.9	10.0	0.593
11	71	62	81	71	30	3.8×10^6	4.7	6.9	5.0	7.0	9.5	0.603
12	63	59	86	87/54	35/26	9.5×10^5	4.6	6.8	5.0	7.0	10.0	0.589
13	84	75	86	81	42^a	8×10^5	4.9	7.1	5.1	7.3^c	11.0	0.573
14	79	77	89	140^d	36^d	1.15×10^6	4.0	7.4	4.5	7.2	9.5	0.568
15	68	60	86	109	47^a	1.6×10^6	5.5	7.3	5.2	7.2	10.0	0.553
16	121	105	94	-	-	2.55×10^6	4.0	7.3	4.6	7.2	10.0	0.543
17	95	80	93	123^d	32^d	1.95×10^5	4.4	7.3	5.0	7.2	11.0	0.501
18	118	117	94	85^d	18^d	1.2×10^6	3.9	7.3	4.5	7.2	10.5	0.521
19	118	114	94	-	-	6.5×10^4	3.9	7.3	4.0	7.3	10.0	0.566
20	106	96	92	88	31	1.85×10^6	2.6	7.3	5.5	7.3	10.0	0.544
Mean	85	74	86	110/76	36/32	5.8130 L	4.9	7.1	5.5	7.1	9.7	0.572
Stan. Dev.	24	24	6	27/31	7/9	0.5115 L	0.8	0.2	0.7	0.2	0.6	0.045

N.S. - No sample

[a] Outside the 40-70% limit.

[b] Outside the 20-80 colony limit.

[c] Not a 24 hr. composite.

[d] >90% depletion (dilution water problem).

[c] Pocket pH meter malfunction, pH from now on taken using laboratory pH meter.

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-2. SUMMARY DATA SHEET, MT. SHASTA, #1 LAGOON INFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Jan. 22	182	49	3.41	14.1	9.07	5.0	0.22	0.045	0.18
23	235	57	3.58	12.5	9.17	3.3	0.23	0.046	0.18
24	275	51	4.03	12.1	11.53	0.6	0.21	0.046	0.16
25	204	58	4.02	11.6	8.57	3.0	0.22	0.050	0.17
26	189	53	3.53	13.3	8.33	5.0	0.35	0.057	0.29
27	182	59	3.97	17.9	9.08	8.8	0.91	0.058	0.86
28	78	59	4.27	17.0	10.54	6.5	0.24	0.048	0.20
29	241	70	3.75	13.3	10.58	2.7	0.23	0.153	0.08
30	108	74	4.76	16.6	10.21	6.4	0.18	0.062	0.12
31	138[a]	70	5.54[a]	20.9[a]	12.98	7.9	0.19	0.064	0.13
Feb. 1	188	70	4.67	17.8	12.56	5.2	0.23	0.049	0.19
2	150	63	4.12	16.5	12.07	4.4	0.19	0.054	0.14
3	169	66	3.76	18.2	11.88	6.3	0.32	0.090	0.23
4	169	59	3.80	14.7	9.38	5.3	0.56	0.072	0.49
5	116	66	3.70	14.8	12.67	2.1	0.17	0.062	0.11
6	207	66	4.37	15.9	11.95	3.9	0.15	0.054	0.10
7	123	63	4.11	13.4	10.08	3.3	0.28	0.065	0.17
8	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
9	82	36	2.49	10.6	8.75	1.8	0.17	0.066	0.11
10	203	44	2.91	12.1	9.64	2.5	0.40	0.062	0.34
11	187	48	4.25	11.3	9.30	2.0	0.39	0.032	0.36
12	117[b]	52[b]	3.60[b]	11.8[b]	10.15[b]	1.6[b]	0.29[b]	0.093[b]	0.20[b]
13	175[b]	79[b]	3.67[b]	12.1[b]	9.82[b]	2.3[b]	0.02[b]	0.012[b]	0.01[b]
14	230	52	4.43	12.7	10.00	2.7	0.21	0.083	0.14
15	184	64	4.24	13.2	10.11	3.1	0.24	0.060	0.18
16	249	64	4.14	16.1	12.19	3.9	0.18	0.071	0.12
17	218	79	4.21	14.0	10.70	3.3	0.20	0.077	0.13
18	243	68	4.63	17.2	12.30	4.9	0.56	0.143	0.42
19	199	70	5.08	15.0	11.59	3.4	0.18	0.119	0.06
20	203	64	4.53	14.0	11.85	2.2	0.22	0.105	0.12
Mean	181	61	4.05	14.4	10.59	3.9	0.27	0.069	0.21
Stan. Dev.	50	10	0.61	2.6	1.38	1.9	0.17	0.031	0.16

N.S. - No sample.

[a] Total sample contained paper, not a 24 hr. composite.

[b] Arrived three weeks late.

TABLE A-3. SUMMARY DATA SHEET, MT. SHASTA, #2 LAGOON EFFLUENT (FIELD)

1977 Date		SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	Temperature Composite Sample °C	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
Jan.	22	24	21	87	21	7	120	12.8	8.2	1.0	13.7	8.3	3.5
	23	15	12	82	19	7	131	11.6	7.9	2.0	12.8	8.1	2.0
	24	29	19	83	33	9	172	12.8	7.9	2.0	14.6	8.2	3.0
	25	35	32	82	26	10	270	11.2	7.4	2.0	12.5	7.6	2.0
	26	19	18	80	24	10	222	11.8	7.8	2.0	13.7	8.1	2.5
	27	33	15	88	22	11	460	12.2	7.6	2.5	13.4	8.0	2.0
	28	23	6	84	19	10	359	12.6	7.7	4.0	16.4[e]	8.3[e]	6.0[e]
	29	39	29	83	20	9	905[a]	14.3	8.1	5.5	16.6	8.4	6.0
	30	29	27	84	24	10	890[a]	12.5	8.1	5.0	14.6	8.4	6.0
	31	33	28	80	39	14[b]	1100[a]	N.S.	N.S.	N.S.	16.4	8.7	4.0
Feb.	1	14	14	N.S.	23[c]	N.S.	>2000[a]	N.S.	N.S.	N.S.	16.0	8.1	4.5
	2	57	37	83	28/30	8/7	>2000[a]	12.4	7.7	6.0	14.6	8.0	5.0
	3	80	6	85	17	6	5300	12.0	7.8	4.5	N.S.	N.S.	N.S.
	4	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
	5	45	32	84	27	13	4×10^4	12.4	7.5	6.0	15.5	8.0	6.0
	6	25	23	83	23	8	1.95×10^4	12.2	7.7	4.0	14.0	8.0	6.5
	7	35	33	82	28	9	7000	10.1	7.5	3.0	N.S.	N.S.	N.S.
	8	N.S.	N.S.	N.S.	N.S.	N.S.	5.1×10^4	N.S.	N.S.	N.S.	11.7	7.4	8.0
	9	45	44	79	38	13[b]	9250	11.6	7.6	4.0	12.0	8.1	6.0
	10	8	7	78	30	10	2000	11.6	7.9	3.5	13.1	8.3	7.0
	11	52	43	78	28	15	1250	11.6	7.9	4.0	13.2	8.4	7.0
	12	41	39	67	30/27	13/13	800	11.1	8.1	4.0	13.0	8.5	7.5
	13	49	47	77	19	8	375	11.0	8.4	4.0	12.8	8.8[f]	7.5
	14	36	35	74	25[d]	-	275	11.3	8.6	4.0	13.8	9.0	7.5
	15	52	48	75	28	8	400	11.9	8.5	4.0	13.8	8.8	7.5
	16	56	50	75	-	-	320	11.0	8.4	3.0	14.6	8.8	8.5
	17	50	43	70	29[d]	3[d]	180	12.2	8.6	5.0	13.9	8.8	8.0
	18	36	36	69	20[d]	4[d]	175	10.8	8.5	3.5	N.S.	N.S.	N.S.
	19	40	40	70	-	-	205	11.4	8.3	5.0	13.6	8.7	8.0
	20	33	32	69	28	3	245	11.3	8.5	5.0	13.4	8.8	8.5
Mean		37	29	79	26/29	9/10	2.8580 L	11.8	8.0	3.8	14.0	8.3	5.8
Stan. Dev.		15	13	6	6/2	3/4	0.9127 L	0.8	0.4	1.3	1.3	0.4	2.2

N.S. - No sample.

[a] Outside the 20-80 colony limit.

[b] Outside the 40-70% limit.

[c] Not 24 hr.

[d] > 90% depletion (dilution water problem).

[e] Sample taken from Balast Pond.

[f] Pocket pH meter malfunction, pH from now on taken using laboratory pH meter.

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-4. SUMMARY DATA SHEET, MT. SHASTA, #2 LAGOON EFFLUENT (UWRL)

1977 Date		Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Jan.	22	89	37	3.17	12.1	9.17	2.9	0.51	0.023	0.49
	23	93	38	3.58	12.0	9.12	2.9	0.57	0.023	0.54
	24	64	41	3.50	12.8	9.17	3.6	0.57	0.023	0.54
	25	104	38	3.45	10.4	7.06	3.3	0.60	0.022	0.58
	26	93	42	3.63	11.2	7.94	3.3	0.55	0.024	0.53
	27	70	40	3.64	12.9	8.63	4.3	0.61	0.023	0.59
	28	72	40	3.54	14.2	8.88	5.3	0.61	0.033	0.58
	29	73	37	3.58	13.1	9.67	3.4	0.74	0.030	0.71
	30	76	37	3.67	13.0	8.18	4.8	0.72	0.027	0.70
	31	83	37	3.40	12.5	7.73	4.8	0.70	0.030	0.67
Feb.	1	75	39	3.43	11.1	10.04	1.1	0.59	0.031	0.56
	2	72	38	3.45	12.0	9.59	2.4	0.60	0.029	0.57
	3	78	43	3.37	13.4	8.21	5.2	0.72	0.034	0.69
	4	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
	5	87	31	3.38	12.0	9.28	2.7	0.52	0.030	0.49
	6	80	31	3.32	11.6	10.21	1.4	0.59	0.027	0.57
	7	81	36	3.77	10.2	8.38	1.8	0.56	0.027	0.54
	8	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
	9	88	32	3.35	11.5	6.67	4.8	0.48	0.029	0.45
	10	112	67	3.52	8.3	7.00	1.3	0.40	0.027	0.36
	11	108	34	3.39	8.4	6.22	2.2	0.35	0.010	0.34
	12	96[a]	37[a]	3.41[a]	10.2[a]	5.93[a]	4.3[a]	0.43[a]	0.045[a]	0.39[a]
	13	81[a]	44[a]	2.67[a]	10.7[a]	5.30[a]	5.4[a]	0.39[a]	0.051[a]	0.35[a]
	14	119	32	3.42	12.7	5.89	6.8	0.56	0.045	0.52
	15	102	20	3.38	8.3	5.85	2.5	0.52	0.054	0.47
	16	139	23	3.39	8.2	6.22	2.0	0.59	0.077	0.51
	17	143	35	3.49	8.2	5.33	2.9	0.97	0.071	0.90
	18	122	38	2.78	8.4	4.96	3.4	0.84	0.109	0.73
	19	106	40	3.22	6.8	5.63	1.2	0.67	0.052	0.62
	20	116	37	3.18	7.6	5.26	2.3	0.80	0.134	0.67
Mean		94	37	3.40	10.8	7.55	3.3	0.60	0.041	0.56
Stan. Dev.		21	8	0.24	2.1	1.68	1.5	0.14	0.028	0.13

N.S. - No sample.

[a] Arrived three weeks late.

TABLE A-5. SUMMARY DATA SHEET, MT. SHASTA, #3 FILTER EFFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
Jan. 22	7	7	71	22	8	14	9.6	7.2	7.1	7.0	3.0
23	17	13	69	22	5	11	8.6	7.1	5.6	6.8	3.0
24	18	17	70	29	8	8	9.4	7.0	5.9	6.8	3.0
25	23	22	67	24	10	24	7.8	6.5	5.1	6.3	2.0
26	4	3	65	21	14	23	8.5	6.7	5.4	6.6	3.0
27	30	12	74	12	7	47	8.4	6.5	5.4	6.4	3.0
28	16	6	71	17	6	46	8.4	6.9	4.7	6.6	4.5
29	42	33	68	22	7	50	9.3	7.1	5.5	6.7	3.0
30	17	16	68	21	6	68	8.0	6.8	5.6	6.5	3.5
31	26	25	66	18	6	69	8.3	6.8	5.7	6.6	4.5
Feb. 1	10	10	63	21	6	240[a]	8.3	6.8	6.8	6.5	3.0
2	32	29	65	19/19	3[b]/3[b]	>200[a]	7.7	6.7	5.1	6.5	4.0
3	3	2	67	17	3	565	6.8	6.7	4.1	6.6	5.0
4	8	4	71	19	8	160	6.2	6.9	2.5	6.7	5.0
5	33	26	67	23[b]	3	1630	8.3	6.5	7.0	6.3	5.5
6	25	23	61	18[b]	3	841	7.2	6.5	5.[illegible]	6.3	6.0
7	32	31	58	21[b]	3	250	6.7	6.8	3.7	6.2	6.0
8	24	23	54	24[b]	6	430	7.7	6.3	4.7	6.2	5.0
9	35	32	50	22[b]	5	360	6.6	6.4	4.5	6.2	5.0
10	24	22	48	25[b]	3	50	6.8	6.5	4.3	6.2	7.0
11	35	30	49	25[b]	3	70	6.6	6.4	4.5	6.0	7.5
12	25	24	50	25[b]/24[b]	3/3	33	6.4	6.3	3.4	6.1	8.0
13	43	40	45	22[b]	3	10	6.4	6.6	1.8	6.4[d]	7.5
14	24	23	43	17[c]	-	42	6.7	6.5	3.6	6.6	9.0
15	42	41	39	35[c]	10[c]	33	6.3	6.5	3.6	6.4	8.5
16	42	38	43	-	-	17	6.0	6.5	2.4	6.3	10.0
17	43	40	43	22[c]	1[c]	13	6.6	6.5	3.5	6.3	9.0
18	43	42	37	12[c]	-	24	6.2	6.5	2.1	6.2	9.0
19	32	31	35	-	-	5[a]	6.4	6.6	3.8	6.4	10.0
20	21	20	43	20	2	6[a]	6.5	6.6	3.0	6.4	9.5
Mean	26	23	57	21/21	5/3	1.7220 L	7.4	6.7	4.5	6.4	5.7
Stan. Dev.	12	12	12	5/3	3/0	0.6633 L	1.1	0.2	1.4	0.2	2.5

[a] Outside the 20-80 colony limit.

[b] Outside the 40-70% limit.

[c] > 90% depletion (dilution water problem).

[d] Pocket pH meter malfunction, pH from now on taken using laboratory pH meter.

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-6. SUMMARY DATA SHEET, MT. SHASTA, #3 FILTER EFFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Jan. 22	64	22	3.12	9.1	6.39	2.7	2.6	0.012	2.6
23	64	17	3.28	8.1	6.48	1.6	3.0	0.016	2.9
24	68	23	3.30	8.1	6.39	1.7	3.3	0.018	3.3
25	57	32	3.27	7.7	5.08	2.6	3.0	0.016	3.0
26	71	26	3.43	6.0	5.12	0.9	2.6	0.017	2.5
27	55	26	3.21	10.1	5.88	4.2	3.0	0.021	3.0
28	54	23	3.19	10.1	5.21	4.9	3.0	0.022	3.0
29	59	21	3.25	7.1	5.50	1.6	4.0	0.023	4.0
30	56	22	3.27	9.3	5.58	3.7	3.7	0.026	3.7
31	54	25	3.18	8.8	5.41	3.4	4.1	0.025	4.1
Feb. 1	53	25	3.25	8.5	6.12	2.4	4.4	0.026	4.3
2	53	21	3.01	8.4	5.83	2.6	3.4	0.024	3.4
3	53	23	3.01	8.8	5.17	3.6	3.4	0.022	3.4
4	49	23	2.94	7.5	5.17	2.3	3.2	0.022	3.1
5	64	14	2.87	7.2	5.81	1.4	6.0	0.073	5.9
6	43	10	2.76	6.2	4.58	1.6	6.3	0.035	6.3
7	44	10	2.63	6.2	3.83	2.4	2.9	0.018	2.9
8	42	12	2.53	6.2	3.33	2.9	2.8	0.018	2.8
9	43	11	2.63	4.7	3.42	1.3	2.8	0.019	2.8
10	67	63	2.98	4.4	3.44	1.0	7.4	0.042	7.4
11	67	18	3.20	3.5	3.00	0.5	7.8	0.048	7.8
12	54[a]	18[a]	2.61[a]	5.3[a]	2.22[a]	3.1[a]	7.0[a]	0.055[a]	7.0[a]
13	56[a]	18[a]	3.27[a]	5.5[a]	1.85[a]	3.7[a]	7.4[a]	0.051[a]	7.4[a]
14	81	15	3.11	2.7	1.70	1.0	7.5	0.045	7.5
15	96	27	3.09	1.8	1.56	0.2	8.0	0.083	7.9
16	101	18	3.07	2.4	1.26	1.1	6.5	0.050	6.5
17	92	16	3.22	1.4	0.93	0.5	7.7	0.058	7.6
18	88	20	2.61	1.1	0.82	0.3	8.5	0.060	8.4
19	83	24	2.58	1.3	0.82	0.5	7.6	0.062	7.5
20	78	18	2.45	1.0	0.70	0.3	7.4	0.054	7.4
Mean	64	21	3.01	5.9	3.95	2.0	5.0	0.035	5.0
Stan. Dev.	16	9	0.28	2.9	2.00	1.3	2.1	0.020	2.1

[a] Arrived three weeks late.

TABLE A-7. SUMMARY DATA SHEET, MT. SHASTA, #4 CHLORINATED EFFLUENT (FIELD)

1977 Date		SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	Temperature Composite Sample °C	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C	Daily Total Flow mgd
Jan.	22	13	4	62	14	9	< 1	10.1	6.9	3.0	8.7	7.0	5.0	0.475
	23	5	4	60	13	8	< 1	9.1	6.5	5.0	5.3	6.5	2.0	0.413
	24	23	11	59	20	10	< 1	10.5	6.6	2.0	5.4	6.4	3.0	0.398
	25	27	23	56	15	8	< 1	8.4	6.7	2.0	4.7	6.5	3.0	0.479
	26	3	2	57	7	8[a]	< 1	10.2	6.5	1.0	5.0	6.4	2.5	N.R.
	27	21	7	56	11	5	< 1	9.2	6.6	3.0	4.0	6.4	3.5	N.R.
	28	17	5	63	10	5	< 1	9.0	6.7	3.0	3.0	6.5	2.5	N.R.
	29	36	28	58	14	6	< 1	10.2	6.9	2.5	5.1	6.6	3.0	0.555
	30	15	13	58	13	8	1	9.0	6.6	2.5	4.6	6.4	3.0	0.551
	31	22	20	55	11	6	< 1	9.3	6.7	3.0	4.1	6.4	3.5	0.75
Feb.	1	7	7	55	15	9	< 1	9.4	6.7	2.5	4.6	6.4	3.5	0.880
	2	55	30	54	14/14	7/7	< 1	9.1	6.5	3.0	3.3	6.2	3.0	1.185
	3	4	3	57	14[a]	8	< 1	8.9	6.7	3.0	2.0	6.4	3.5	0.715
	4	4	3	64	12	9[a]	< 1	8.4	6.8	3.0	1.2	6.7	4.0	0.413
	5	32	23	60	13	12[a]	< 1	10.1	6.5	3.0	5.5	6.2	3.5	0.490
	6	15	14	51	9	6	< 1	8.7	6.5	3.5	3.4	6.2	4.0	0.262
	7	30	29	47	13	6	< 1	8.3	6.6	5.0	4.2	6.4	4.0	0.250
	8	16	14	43	16	11[a]	< 1	9.4	6.3	4.0	4.5	5.9	4.0	0.634
	9	30	29	40	16[a]	9[a]	79	8.5	6.3	3.5	2.1	6.0	6.0	0.614
	10	14	13	39	18	7	< 1	8.4	6.4	4.0	1.7	6.0	6.0	0.490
	11	28	23	39	18[a]	9[a]	< 1	8.5	6.3	4.0	1.4	6.0	7.0	0.419
	12	21	20	38	18/17	8/9	< 1	8.5	6.3	4.5	1.2	5.7	7.0	0.357
	13	31	30	35	19[b]	10[a]	< 1	8.2	6.5	5.0	1.5	6.2[c]	8.0	0.315
	14	6	6	33	8[b]	3[b]	< 1	8.1	6.5	5.0	1.1	6.2	7.5	0.370
	15	36	32	22	24[a]	15	< 1	8.3	6.2	5.0	1.4	6.0	8.0	0.964
	16	22	20	30	-	-	< 1	8.1	6.4	5.5	0.8	6.2	8.0	0.494
	17	36	31	35	15[b]	5[b]	< 1	8.3	6.4	5.5	1.4	6.0	8.0	0.622
	18	29	28	15	9[b]	1[b]	< 1	7.7	6.5	5.5	1.0	6.0	8.5	0.125
	19	25	25	35	-	-	< 1	7.9	6.5	6.0	1.8	6.2	9.0	0.572
	20	10	9	37	11	5	< 1	8.3	6.5	3.5	2.2	6.2	8.0	0.526
Mean		21	17	47	14/15	8/8	0.0632 L	8.9	6.5	3.7	3.2	6.3	5.1	0.530
Stan. Dev.		12	10	13	4/2	3/1	0.3465 L	0.8	0.2	1.3	1.9	0.3	2.2	0.227

[a] Outside the 40-70% limit.

[b] > 90% depletion (dilution water problem).

/ - BOD_5/BOD_5 with nitrification inhibitor.

[c] Pocket pH meter malfunction, pH from now on taken using laboratory pH meter.

N.R. - No reading.

L = Log_{10}

TABLE A-8. SUMMARY DATA SHEET, MT. SHASTA, #4 CHLORINATED EFFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Jan. 22	57	27	2.97	7.8	5.83	2.0	2.4	0.008	2.4
23	59	31	3.14	7.8	5.93	1.9	2.6	0.008	2.6
24	57	20	3.25	8.5	6.16	2.3	2.9	0.008	2.9
25	61	28	3.13	6.9	5.12	1.8	3.0	0.007	3.0
26	57	28	3.30	5.2	5.04	0.2	2.7	0.008	2.7
27	51	27	3.18	8.7	5.71	3.0	2.7	0.009	2.7
28	50	26	3.12	9.2	5.58	3.6	3.0	0.009	3.0
29	52	24	3.10	9.3	5.25	4.0	3.5	0.009	3.5
30	54	26	3.05	9.3	5.17	4.1	3.5	0.010	3.5
31	32	24	3.05	8.0	5.41	2.6	3.7	0.013	3.7
Feb. 1	50	24	2.89	8.4	5.79	2.6	3.9	0.009	3.9
2	49	35	2.95	7.9	3.93	4.0	3.3	0.015	3.3
3	53	43	2.96	7.8	4.79	3.0	3.3	0.010	3.3
4	45	22	2.62	6.3	5.04	1.3	3.2	0.013	3.2
5	45	16	2.65	7.5	4.62	2.9	4.9	0.016	4.9
6	36	13	2.52	5.5	5.47	<0.1	5.4	0.013	5.4
7	35	13	2.43	5.2	4.21	1.0	3.1	0.010	3.1
8	35	14	2.34	5.4	4.17	1.2	3.1	0.012	3.1
9	33	16	2.52	5.0	3.46	1.5	2.9	0.013	2.9
10	50	29	2.78	3.6	2.92	0.7	7.0	0.013	7.0
11	54	18	2.84	6.0	2.44	3.5	7.9	0.069	7.8
12	49[a]	18[a]	2.47[a]	4.8[a]	2.67[a]	2.1[a]	9.0[a]	0.012[a]	9.0[a]
13	52[a]	29[a]	2.45[a]	4.6[a]	1.82[a]	2.8[a]	9.6[a]	0.013[a]	9.6[a]
14	67	18	2.81	2.6	2.48	0.1	7.7	0.005	7.7
15	81	31	2.76	2.9	2.52	0.4	9.1	0.016	9.1
16	76	25	2.87	3.8	2.15	1.6	5.6	0.008	5.6
17	72	25	2.92	2.2	1.70	0.5	7.2	0.008	7.2
18	73	24	2.45	1.3	0.63	0.7	6.6	0.019	6.6
19	71	30	2.45	1.6	0.78	0.8	8.7	0.022	8.7
20	69	22	2.38	1.2	0.67	0.5	9.1	0.007	9.1
Mean	54	24	2.81	5.8	3.91	1.9	5.0	0.013	5.0
Stan. Dev.	13	7	0.29	0.3	1.74	1.3	2.5	0.011	2.5

[a] Arrived three weeks late.

TABLE A-9. SUMMARY DATA SHEET, MT. SHASTA, #1 LAGOON INFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C	Daily Total Flow mgd
July 11	122	110	117	124	39	1.6×10^6	2.7	7.5	0.5	6.6	26.0	0.667
12	64	54	116	106	44	2.95×10^6	3.1	6.6	0.8	6.6	22.0	0.644
13	112	97	107	110	44	2.9×10^6	4.1	7.6	2.8	6.7	19.5	0.656
14	132	121	112	148	49	2.9×10^6	3.8	7.9	4.3	7.0	19.5	0.645
15	45	33	109	87	57	3.7×10^6	3.8	7.7	2.9	6.7	21.0	0.585
16	97	85	110	110	41	2.55×10^6	3.0	7.0	4.4	6.8	22.0	0.625
17	44	42	106	118	49	1.75×10^6	2.9	7.9	3.3	6.6	21.0	-
18	78	71	107	130	46	4.6×10^6	2.8	7.2	2.6	6.6	22.5	0.614
19	108	83	105	73	46	TNC	3.4	7.2	2.4	6.8	20.0	0.697
20	142	123	110	173	41	7.3×10^6	3.6	7.2	4.0	6.6	20.0	0.633
21	78	46	106	125	32	2.3×10^6	3.1	7.3	2.1	6.7	20.0	-
22	86	68	105	87	45	1.8×10^6	3.4	7.3	3.3	6.7	20.0	-
23	101	70	109	83	45	1.25×10^6	3.4	7.5	3.5	6.7	22.0	0.659
24	73	61	118	72	44	2.7×10^6	2.8	7.4	4.8	7.0	20.0	0.627
25	63	54	110	92	32	5.9×10^6	2.8	7.4	2.2	6.7	21.0	0.628
26	50	39	109	80	40	3.15×10^6	2.9	7.2	2.5	6.8	23.5	0.598
27	138	114	110	133	51	1.2×10^6	2.4	7.2	3.0	6.8	22.0	0.601
28	47	39	110	127	38	3.05×10^6	2.2	7.3	2.8	6.7	23.0	0.587
29	125	116	110	124/114	39/42	3.0×10^6	2.8	7.2	3.1	6.8	21.0	0.597
30	45	41	109	92	47	2.55×10^6	2.5	7.2	3.1	6.6	21.5	0.583
31	51	41	109	129	52	4.5×10^6	1.0	7.2	4.1	6.8	22.0	0.600
Aug. 1	39	31	114	91	53	1.6×10^6	1.9	7.2	4.5	6.8	22.5	0.578
2	37	34	111	79	42	1.55×10^6	1.1	7.3	3.6	6.8	21.5	0.609
3	67	59	111	113	47	2.2×10^6	1.6	7.1	4.3	6.9	22.0	0.574
4	54	41	108	133	41	1.65×10^6	2.0	7.1	4.4	6.8	21.5	0.613
5	130	119	102	110/141	48/45	2.0×10^6	2.4	7.1	1.6	6.8	21.5	± 0.450
6	152	137	107	133	50	5.6×10^6	2.0	7.2	2.7	6.8	20.0	-
7	116	88	107	140	47	2.3×10^6	2.6	7.2	3.5	6.8	20.0	-
8	160	143	100	143	48	1.4×10^6	2.3	7.2	4.0	6.8	20.0	-
9	103	89	104	136	44	3.3×10^6	1.8	7.2	0.3	6.8	20.0	±0.450
10	46	38	99	123	50	1.55×10^6	2.5	7.2	2.8	6.8	21.0	±0.450
11	90	72	104	218	53	2.8×10^6	1.5	7.1	3.2	6.8	21.5	±0.450
12	66	56	110	110	46	4.1×10^6	1.7	7.2	2.0	6.5	21.0	0.561
13	121	99	119	133	47	3.15×10^6	1.3	7.2	3.6	6.8	21.5	0.530
14	90	80	118	165	36	2.1×10^6	2.0	7.0	2.8	7.0	20.5	0.466
15	38	32	124	148	63	2.8×10^6	1.5	7.2	3.4	6.8	21.5	0.500
16	111	99	115	190	53	1.5×10^6	1.4	7.2	1.7	6.8	22.0	0.466
17	66	64	114	140	42	3.45×10^6	2.1	7.1	2.0	6.7	21.0	0.460
18	107	94	105	160	56	3.4×10^6	3.0	7.0	3.6	6.8	21.5	0.475
19	15	12	N.S.	N.S.	N.S.	3.2×10^6	N.S.	N.S.	2.8	6.7	23.5	0.480
20	133	131	117	153	93	2.85×10^6	3.1	7.1	3.2	6.8	21.0	0.448
Mean	86	74	110	121/127	47/43	6.5290 L	2.5	7.3	3.0	6.7	21.3	0.566
Stan. Dev.	37	34	5	32/19	10/2	1.0190 L	0.8	0.2	1.1	0.1	1.3	0.077

N.S. - No sample.

TNC - Too numerous to count.

/ - BOD_5/BOD_6 with nitrification inhibitor.

L = Log_{10}

TABLE A-10. SUMMARY DATA SHEET, MT. SHASTA, #1 LAGOON INFLUENT (UWRL)

1977 Date		Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
July	11	197	53	7.14	18.8	17.5	1.3	0.25	0.000	0.25
	12	168	47	6.01	16.8	15.0	1.8	0.25	0.010	0.24
	13	160	74	5.67	17.0	15.8	1.2	0.25	0.015	0.24
	14	193	62	6.65	15.4	14.9	0.5	0.30	0.025	0.28
	15	213	70	5.44	14.9	14.6	0.3	0.30	0.010	0.29
	16	179	47	5.36	15.1	13.7	1.4	0.35	0.040	0.31
	17	192	92	4.89	15.8	13.3	2.5	0.35	0.025	0.32
	18	53	40	5.68	12.9	12.8	0.1	0.35	0.045	0.30
	19	100	62	5.61	16.2	13.7	2.5	0.45	0.055	0.40
	20	299	245	6.52	15.4	9.7	5.7	0.40	0.060	0.34
	21	280	196	5.11	14.1	9.0	5.1	0.35	0.085	0.26
	22	239	227	6.07	13.4	9.8	3.6	0.15	0.000	0.15
	23	286	208	6.31	13.7	9.8	3.9	0.35	0.110	0.24
	24	350	284	5.75	14.1	10.7	3.4	0.45	0.130	0.32
	25	306	235	5.42	15.3	8.6	6.7	0.45	0.155	0.30
	26	237	177	6.29	17.2	15.1	2.1	0.80	–	–
	27	195	139	6.97	17.0	14.6	2.4	0.20	0.025	0.18
	28	288	226	5.30	17.0	14.2	2.8	1.05	0.85	0.20
	29	250	243	5.92	14.1	13.7	0.4	1.15	0.93	0.22
	30	140	118	5.30	15.0	14.3	0.7	0.55	0.31	0.24
	31	179	140	5.47	14.1	13.0	1.1	1.10	0.95	0.15
Aug.	1	286	281	--	16.8	12.7	4.1	0.60	0.42	0.18
	2	303	268	5.22	15.8	12.4	3.4	0.60	0.42	0.18
	3	268	250	5.93	15.0	12.1	2.9	0.60	0.40	0.20
	4	222	186	5.22	15.5	12.7	2.8	0.60	0.38	0.22
	5	329	328	6.54	16.9	12.4	4.5	0.45	0.10	0.35
	6	288	283	6.23	16.7	12.9	3.8	0.90	0.47	0.43
	7	345	327	4.98	16.5	12.1	4.4	1.00	0.52	0.48
	8	319	303	5.22	16.7	13.4	3.3	0.85	0.44	0.41
	9	347	328	3.75	17.5	12.8	4.7	0.75	0.50	0.25
	10	312	301	5.25	16.9	11.7	5.2	0.75	0.44	0.31
	11	303	273	5.62	16.7	12.3	4.4	0.65	0.32	0.33
	12	343	340	6.31	18.1	9.5	8.6	0.60	0.32	0.28
	13	379	371	7.01	18.2	14.3	3.9	0.65	0.38	0.27
	14	444	407	5.95	17.5	13.2	4.3	0.75	0.41	0.34
	15	293	274	6.50	17.9	12.1	5.8	–	--	--
	16	289	264	6.50	19.6	11.7	7.9	0.75	0.36	0.39
	17	377	361	5.98	19.5	14.7	4.8	0.75	0.40	0.35
	18	354	343	6.45	18.3	15.1	3.2	0.85	0.38	0.47
	19	N.S.	N.S.	6.54	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
	20	413	409	6.66	19.1	16.3	2.8	0.90	0.36	0.54
Mean		268	215	5.87	16.3	13.0	3.4	0.56	0.301	0.29
Stan. Dev.		85	107	0.69	1.7	2.0	2.0	0.27	0.254	0.09

N.S. - No sample.

TABLE A-11. SUMMARY DATA SHEET, MT. SHASTA, #2 LAGOON EFFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
July 11	25	16	111	13	7	13	8.5	8.5	9.3	8.7	26.5
12	18	16	111	9	5	7	7.2	8.4	9.5	8.7	21.0
13	38	23	103	9	5	23	9.0	8.8	11.3	8.8	23.0
14	46	38	101	9	4	11	9.8	8.7	12.2	9.0	23.5
15	59	43	99	13	6	11	9.2	8.8	11.3	9.1	25.0
16	65	44	96	9	3	25	9.5	8.8	13.3	9.0	25.0
17	66	51	81	15	4	8	9.3	8.8	12.6	9.2	24.0
18	60	38	84	14	4	21	9.1	9.2	11.8	9.1	25.0
19	79	52	77	14	5	< 1	9.0	9.2	10.4	9.4	24.5
20	78	56	73	15	3	< 1	9.0	9.3	13.2	9.6	25.0
21	99	71	70	12	3	29	8.9	9.2	12.2	9.6	24.0
22	74	37	71	14	3	23	10.0	9.4	12.4	9.7	25.0
23	88	56	71	18	7	10	8.8	9.2	12.0	9.4	25.0
24	92	62	70	17	5	15	9.1	9.1	11.1	9.6	24.0
25	84	60	69	13	5	21	9.8	9.1	9.0	9.3	24.0
26	64	43	69	18	5	15	9.5	8.8	12.7	9.2	24.0
27	76	55	69	20	7	9	8.9	8.8	9.5	9.2	24.0
28	64	62	69	19	6	15	10.6	9.2	10.5	9.5	24.0
29	92	64	69	26/18	7/6	11	10.6	9.2	11.5	9.5	23.0
30	79	52	68	21	7	11	9.3	9.1	11.4	9.4	24.0
31	58	43	66	15	6	11	8.7	9.1	9.9	9.4	26.0
Aug. 1	77	54	65	21	10	11	8.8	9.1	10.5	9.4	26.0
2	47	35	65	23	6	10	8.3	8.9	10.6	9.3	26.5
3	62	41	62	20	6	13	9.8	8.8	11.8	9.5	26.0
4	89	57	65	18	7	17	9.6	9.0	13.0	9.4	26.0
5	85	56	64	23/13	7/5	12	9.8	9.2	12.9	9.6	26.0
6	95	64	63	24	6	27	10.2	9.2	12.0	9.5	23.0
7	109	73	63	21	6	15	9.8	9.1	10.2	9.4	23.5
8	88	64	61	18	6	19	9.7	9.2	9.9	9.4	23.5
9	49	38	63	23	6	62	9.1	9.0	11.0	9.4	24.0
10	62	38	61	19	7	11	9.7	9.1	11.5	9.4	25.0
11	60	30	63	20	7	56	9.5	9.1	11.4	9.2	26.0
12	88	58	68	22	6	58	9.4	9.0	11.1	9.3	25.0
13	61	22	67	23	7	38	9.8	9.1	11.8	9.6	24.5
14	69	36	67	24	5	137	9.5	9.1	11.6	9.5	23.0
15	47	30	65	25	8	42	10.4	9.1	11.2	9.4	24.0
16	84	56	68	27	6	121	9.7	9.2	11.5	9.4	24.0
17	58	34	68	24	7	145	9.6	9.0	10.5	9.5	23.0
18	61	51	69	31	7	141	8.3	9.0	12.8	9.4	23.0
19	67	40	69	27	7	139	10.7	9.1	13.5	9.5	25.5
20	54	51	72	23	7	48	9.1	9.0	10.3	9.2	23.5
Mean	69	47	73	19/15	6/5	1.2910 L	9.4	9.0	11.4	9.3	24.4
Stan. Dev.	19	14	14	5/3	1/1	0.4822 L	0.7	0.2	1.2	0.2	1.2

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-12. SUMMARY DATA SHEET, MT. SHASTA, #2 LAGOON EFFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
July 11	39	25	4.51	12.7	12.0	0.7	0.50	0.17	0.33
12	49	21	4.53	11.8	11.1	0.7	0.60	0.56	0.04
13	38	29	4.53	12.0	10.3	1.7	0.75	0.32	0.43
14	43	20	4.42	10.5	9.81	0.7	0.85	0.36	0.49
15	44	18	4.55	10.7	9.54	1.2	0.95	0.010	0.94
16	49	16	4.53	10.4	7.36	3.1	1.25	0.56	0.69
17	45	36	4.71	11.3	7.41	3.9	1.60	0.84	0.76
18	37	25	4.84	11.9	6.14	5.8	1.85	1.06	0.79
19	30	26	4.68	12.9	5.73	7.2	2.05	1.12	0.93
20	62	41	4.95	12.9	2.54	10.4	2.40	1.34	1.06
21	45	33	5.13	10.6	2.65	8.0	2.20	--	–
22	135	131	5.13	10.9	2.31	8.6	2.30	1.52	1.48
23	129	117	5.34	11.3	2.63	8.7	2.55	1.62	0.93
24	124	120	5.13	11.7	2.31	9.4	2.65	1.78	0.87
25	128	122	5.73	12.8	1.50	11.3	3.30	1.76	1.54
26	131	125	5.50	11.0	4.81	6.2	3.40	1.88	1.52
27	126	117	5.06	9.9	4.23	5.7	3.20	1.76	1.44
28	131	125	5.20	10.4	0.50	9.9	4.00	--	–
29	126	118	5.19	7.1	3.30	3.8	3.20	1.78	1.42
30	127	117	5.20	10.4	3.00	7.4	3.20	1.72	1.48
31	122	119	5.12	9.0	3.00	6.0	2.80	1.66	1.14
Aug. 1	167	162	--	11.1	2.91	8.2	3.00	1.74	1.26
2	169	167	5.19	10.4	2.65	7.8	1.40	0.60	0.80
3	170	168	5.22	11.2	2.41	8.8	3.20	1.84	1.36
4	161	160	5.30	12.9	2.34	10.6	1.40	0.72	0.68
5	164	145	4.86	11.8	4.02	7.8	3.20	1.82	1.38
6	157	149	5.12	11.3	4.14	7.2	0.80	0.12	0.68
7	170	166	4.36	10.9	2.95	8.0	1.40	0.64	0.76
8	165	160	4.24	10.6	4.31	6.3	3.40	1.80	1.60
9	153	150	4.30	12.7	1.96	10.8	3.15	1.70	1.45
10	160	154	4.11	10.6	1.90	8.7	3.05	2.00	1.05
11	152	144	4.31	9.8	2.34	7.5	3.20	1.86	1.34
12	166	162	5.65	9.9	2.63	7.3	3.15	1.94	1.21
13	165	156	5.63	9.2	1.71	7.5	3.20	2.06	1.14
14	157	150	5.73	9.8	2.06	7.8	3.60	1.82	1.78
15	175	171	5.50	10.6	2.24	8.4	3.40	1.56	1.84
16	172	167	6.11	12.9	3.42	9.5	3.55	1.92	1.63
17	169	168	5.48	14.1	2.81	11.3	3.70	1.52	2.18
18	168	167	5.60	11.8	2.71	9.1	3.75	1.62	2.13
19	174	171	6.00	10.6	2.63	8.0	3.85	1.74	2.11
20	173	172	6.25	11.9	3.05	8.9	4.20	1.88	2.32
Mean	124	115	5.07	11.1	4.09	7.1	2.57	1.35	1.20
Stan. Dev.	52	57	0.54	1.3	2.84	2.9	1.07	0.62	0.53

TABLE A-13. SUMMARY DATA SHEET, MT. SHASTA, #3 INTERMITTENT SAND FILTER EFFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
July 11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
23	3	1	18	6	5.4	<1	7.7	8.3	5.1	7.4	24.0
24	5	2	27	3	2.3	<1	7.7	7.6	6.0	7.4	22.5
25	14	6	32	5	5	<1	8.4	7.2	6.0	7.2	23.5
26	12	1	35	2	2	<1	8.1	7.0	6.1	7.0	23.0
27	21	3	32	5	5	<1	7.9	7.1	6.0	6.8	23.5
28	3	2	33	6	5	<1	8.5	7.4	6.2	7.1	24.0
29	29	20	34	6/7	5/5	<1	7.7	7.3	6.5	7.1	22.5
30	19	6	36	4	4	5	6.8	7.2	5.6	6.9	23.5
31	4	3	37	3	3	<1	6.4	6.9	5.5	7.1	24.0
Aug. 1	23	11	41	7	7	<1	6.6	7.2	6.4	7.1	26.0
2	13	6	42	3	3	3	8.2	7.3	5.9	7.1	27.0
3	5	2	49	6	2	1	7.4	7.3	6.5	7.1	26.0
4	19	1	40	3	2	9	8.2	7.1	6.2	7.5	25.5
5	19	6	43	2/2[a]	2/2[a]	7	8.3	7.2	6.4	7.3	25.0
6	3	0	43	2	2	7	8.6	7.1	6.3	7.7	23.5
7	12	1	41	3	3	7	8.5	7.1	6.4	7.0	23.5
8	24	22	43	2	2	9	8.5	7.1	6.9	6.9	23.5
9	6	4	46	2	2	10	8.0	7.1	6.1	6.9	24.0
10	18	9	42	3	2	5	8.1	6.9	5.8	6.8	25.0
11	10	1	47	3	2	6	8.1	7.1	6.3	6.8	26.5
12	35	22	49	3	2	17	8.1	6.9	6.2	6.9	23.0
13	3	3	47	5	4	<1	6.7	7.1	6.6	6.7	22.5
14	5	2	46	2	2	7	6.5	6.9	6.0	7.3	22.5
15	8	2	55	3	3	<1	6.7	7.2	6.4	6.9	22.5
16	24	14	50	3	2	<1	6.4	7.1	5.7	6.9	23.5
17	1	0	59	2	2	7	7.5	7.1	6.3	6.8	22.0
18	10	9	52	3	3	1	8.7	7.2	6.8	6.8	22.0
19	15	12	47	3	3	<1	8.1	7.3	6.3	6.8	23.5
20	11	7	53	3	3	<1	7.7	7.1	5.5	6.8	23.0
Mean	13	7	42	4/5	3/3	0.3813 L	7.7	7.2	6.1	7.0	23.8
Stan. Dev.	9	6	9	1/3	1/2	0.4466 L	0.7	0.3	0.4	0.2	1.3

[a] Outside the 40-70% limit.

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

Table A-14. SUMMARY DATA SHEET, MT. SHASTA, #3 INTERMITTENT SAND FILTER EFFLUENT (UWRL)

1977 Date		Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
July	23	111	101	0.97	10.6	0.16	10.4	--	0.13	--
	24	115	114	1.63	11.1	0.25	10.8	--	0.13	--
	25	114	110	1.84	10.6	<0.01	10.6	10.6	0.03	10.6
	26	122	117	4.84	6.7	0.74	6.0	6.4	0.18	6.2
	27	118	113	4.74	6.4	0.33	6.1	4.4	0.05	4.3
	28	124	118	4.81	6.8	0.14	6.7	4.6	0.19	4.4
	29	118	111	4.81	6.4	0.50	5.9	4.2	0.12	4.1
	30	122	116	4.50	8.2	0.43	7.8	5.7	0.10	5.6
	31	116	110	4.11	6.6	0.14	6.5	3.8	0.09	3.7
Aug.	1	132	128	5.44	9.1	0.82	8.3	3.6	0.03	3.6
	2	128	120	2.94	8.4	0.51	7.9	4.6	0.10	4.5
	3	132	127	3.07	8.5	0.29	8.2	4.5	0.09	4.4
	4	138	135	3.71	9.1	0.21	8.9	4.6	0.06	4.5
	5	134	123	2.85	10.4	0.38	10.0	4.3	0.06	4.2
	6	129	117	5.14	10.4	0.50	9.9	3.3	0.02	3.3
	7	135	125	3.50	10.2	0.46	9.7	4.6	0.04	4.6
	8	142	126	3.35	8.6	0.88	7.7	4.0	0.04	4.0
	9	140	133	3.54	10.5	0.21	10.3	2.6	0.04	2.6
	10	142	142	3.40	8.8	0.13	8.7	2.8	0.03	2.8
	11	138	132	3.44	7.3	<0.01	7.3	3.3	0.05	3.2
	12	148	135	4.62	7.4	0.33	7.1	2.8	0.06	2.7
	13	133	127	4.40	7.6	0.13	7.5	2.9	0.03	2.9
	14	133	126	4.29	8.1	<0.01	8.1	3.1	0.04	3.1
	15	136	126	3.82	7.3	1.31	6.0	3.4	0.02	3.4
	16	138	132	4.32	7.7	0.91	6.8	3.0	0.01	3.0
	17	130	121	3.36	9.7	0.41	9.3	3.3	0.03	3.3
	18	121	118	4.35	10.4	0.32	10.1	3.2	0.07	3.1
	19	134	133	4.12	9.0	1.32	7.7	2.6	0.03	2.6
	20	133	131	4.17	8.8	0.09	8.7	3.5	0.02	3.5
Mean		129	123	3.80	8.6	0.41	8.2	4.1	0.07	4.0
Stan. Dev.		10	9	1.05	1.5	0.35	1.5	1.6	0.05	1.6

TABLE A-15. SUMMARY DATA SHEET, MT. SHASTA, #3 SLOW SAND FILTER EFFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
July 11											
12											
13											
14											
15											
16	23	6	73	3	2	15	5.9	7.7	2.6	7.3	26.0
17											
18	5	1	64	4	4	17	4.60	8.1	1.90	7.8	24.0
19	14	10	54	5	5	< 1	6.0	8.0	2.3	7.4	24.5
20	18	4	46	4	4	TNC	8.2	8.2	4.6	7.7	25.0
21	20	6	54	3	2	31	-	-	5.0	8.1	24.5
22	9	9	57	2	2	9	8.0	8.0	6.5	7.4	26.0
23	8	2	63	7	6	3	7.7	7.9	5.5	8.2	25.0
24	28	20	47	3	3	33	7.7	7.9	5.7	8.1	25.0
25	23	17	32	2	2	TNC	8.4	7.7	5.9	7.8	24.0
26	13	3	52	2	2	4	8.1	7.7	4.6	7.3	23.5
27	24	8	55	2	2	< 1	7.9	7.5	5.5	7.5	25.0
28	14	12	60	2	2	< 1	8.5	7.3	5.9	7.3	25.0
29											
30											
31											
Aug. 1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13	9	4	54	4	3	3	7.7	7.5	6.4	7.3	25.5
14	11	3	59	2	2	13	7.7	7.5	5.9	7.4	24.0
15	12	0	57	5	5	3	8.1	7.4	6.4	7.7	23.5
16	22	14	52	1	1	5	7.5	7.3	6.0	7.5	25.0
17	4	2	52	2	2	9	7.4	7.3	5.6	7.5	23.5
18	13	10	51	4	4	3	9.2	7.3	5.2	7.3	23.0
19	15	12	56	2	2	5	7.2	7.1	5.1	7.2	26.0
20	7	5	67	3	2	4	7.6	7.3	5.2	7.5	24.5
Mean	15	8	55	3/0	3/0	0.5809 L	7.5	7.6	5.1	7.6	24.6
Stan. Dev.	7	5	9	1/0	1/0	0.5169 L	1.0	0.3	1.3	0.3	0.9

L = Log_{10}
TNC - Too numerous to count.

TABLE A-16. SUMMARY DATA SHEET, MT. SHASTA, #3 SLOW SAND FILTER EFFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
July 16	39	11	3.00	8.5	0.62	7.9	4.9	0.00	4.9
18	44	40	2.74	8.9	1.23	7.7	3.7	0.01	3.7
19	36	30	3.42	10.6	0.71	9.9	2.1	0.01	2.1
20	25	17	3.15	9.9	0.95	9.0	4.3	0.73	3.6
21	30	16	2.43	8.7	0.83	7.9	4.0	0.01	4.0
22	123	115	2.99	9.4	1.15	8.2	4.1	0.01	4.1
23	104	100	1.65	10.1	<0.01	10.1	--	0.23	--
24	99	93	3.05	10.5	<0.01	10.5	3.6	0.40	3.2
25	100	92	2.14	10.1	<0.01	10.1	3.3	0.01	3.3
26	118	111	4.78	10.5	1.50	9.0	3.4	0.04	3.4
27	105	95	4.66	9.7	0.08	9.6	2.8	0.02	2.8
28	118	114	4.58	9.8	<0.01	9.8	2.1	0.02	2.1
Aug. 13	106	102	3.34	6.9	<0.01	6.9	4.9	0.04	4.9
14	95	92	3.42	7.4	0.29	7.1	2.3	0.03	2.3
15	124	116	3.82	8.1	0.48	7.6	1.6	0.01	1.6
16	121	118	3.65	8.3	0.91	7.4	1.4	0.01	1.4
17	122	116	3.85	9.0	0.23	8.8	1.5	0.02	1.5
18	114	111	3.77	9.8	0.55	9.2	1.7	0.02	1.7
19	132	132	4.14	8.8	0.27	8.5	1.5	0.01	1.5
20	132	132	4.14	8.4	<0.01	8.4	1.4	0.01	1.4
Mean	94	88	3.44	9.2	0.49	8.7	2.9	0.09	2.8
Stan. Dev.	37	40	0.83	1.0	0.47	1.1	1.2	0.18	1.2

TABLE A-17. SUMMARY DATA SHEET, MT. SHASTA, #4 CHLORINATED FILTER EFFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C	Daily Total Flow mgd
July 11												
12												
13												
14												
15												
16	22	5	68	5	5	<1	7.0	7.4	5.3	7.1	26.0	.
17												
18	8	4	53	8	7	<1	6.2	7.4	4.2	7.2	24.0	0
19	10	2	50	7	6	<1	7.2	7.5	2.3	6.7	23.5	0
20	14	5	38	5	4	<1	8.6	7.4	4.0	6.8	23.5	0
21	25	6	39	3	3	<1	7.6	7.3	5.9	7.3	25.0	0
22	13	2	37	3	2	<1	8.1	7.6	6.2	7.2	24.5	±0.125
23	18	6	39	4	3	<1	7.7	7.4	5.9	7.1	25.5	0.498
24	4	3	35	3	3	<1	7.7	7.4	5.9	7.1	24.0	0.466
25	21	12	33	2	2	<1	8.0	7.3	6.4	7.0	23.5	0.482
26	5	2	32	3	3	<1	7.9	7.2	6.1	6.7	24.5	0.376
27	21	6	32	3	3	1	7.6	7.0	6.2	6.6	25.0	0.276
28	7	6	28	3	2	1	7.9	7.2	6.4	6.7	24.5	0.219
29	24	15	28	3/3	3/3	<1	8.4	6.9	7.0	6.8	23.5	±0.219
30	18	9	25	3	3	1	8.1	7.0	6.8	6.6	25.0	±0.219
31	2	1	32	2	2	<1	7.6	6.9	6.4	6.6	25.5	±0.218
Aug. 1	24	8	29	3	3	<1	8.1	7.0	6.9	6.5	25.0	0.174
2	19	13	23	2	2	<1	7.8	6.8	6.6	6.4	26.0	0.175
3	9	1	34	3	3	<1	8.2	7.0	7.0	6.6	24.0	0.173
4	10	1	28	2	2	7	8.0	6.9	7.1	6.6	24.5	0.193
5	9	5	30	2/2^a	1/2^a	3	8.1	6.9	6.9	6.8	25.0	0.190
6	2	2	31	3	2	<1	8.8	6.8	7.3	6.5	23.0	0.169
7	19	7	30	2	2	<1	8.4	6.8	7.0	6.4	23.0	0.216
8	17	13	28	2	2	1	8.5	7.0	7.1	6.5	23.0	0.181
9	5	4	38	1	1	3	8.2	7.0	6.6	6.6	24.0	0.189
10	16	2	32	2	2	8	8.4	6.9	6.8	6.4	22.5	0.214
11	12	2	31	2	2	<1	8.0	6.9	6.6	6.5	26.0	0.218
12	24	18	37	2	1	2	8.2	6.8	6.8	6.6	25.5	0.277
13	10	8	33	3	2	<1	8.1	7.1	6.6	6.7	24.5	0.404
14	6	1	45	2	1	<1	7.8	7.0	6.4	6.8	23.0	0.387
15	5	5	45	3	2	<1	8.0	7.1	7.1	6.8	25.0	0.412
16	23	14	38	2	1	<1	7.6	6.8	6.0	6.7	25.0	0.281
17	4	2	45	3	2	<1	7.6	7.1	6.5	6.7	23.5	0.253
18	3	2	39	3	3	<1	8.0	7.0	6.7	6.5	23.5	0.383
19	16	14	36	3	3	11	8.4	6.8	6.8	6.5	24.5	0.187
20	13	10	63	3	3	2	8.5	6.7	6.6	6.4	23.5	0.170
Mean	13	6	37	3/2	3/3	0.1242 L	8.0	7.1	6.3	6.7	24.3	0.265
Stan. Dev.	7	5	10	1/1	1/1	0.2824 L	0.5	0.2	1.0	0.2	1.0	0.107

^{a}Outside the 40-70% limit.

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-18. SUMMARY DATA SHEET, MT. SHASTA, #4 CHLORINATED FILTER EFFLUENT (UWRL)

1977 Date		Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
July	16	36	12	2.58	6.8	1.02	5.8	5.8	0.00	5.8
	18	46	20	2.73	8.6	0.47	8.1	4.1	0.01	4.1
	19	46	36	3.02	8.5	0.38	8.1	2.2	0.01	2.2
	20	19	15	3.00	8.0	0.09	7.9	4.1	0.02	4.1
	21	33	14	2.40	6.9	0.57	6.3	3.7	0.00	3.7
	22	102	85	1.79	7.7	<0.01	7.7	9.2	0.00	9.2
	23	80	75	1.60	8.1	<0.01	8.1	17.5	0.50	17.0
	24	83	77	2.08	8.6	<0.01	8.6	9.5	0.00	9.5
	25	77	56	2.06	8.3	<0.01	8.3	7.0	0.00	7.0
	26	107	103	3.40	2.7	1.50	1.2	5.6	0.01	5.6
	27	103	99	3.66	2.9	0.20	2.7	4.8	0.01	4.8
	28	103	103	3.70	3.0	0.46	2.5	4.2	0.02	4.2
	29	110	103	4.11	3.6	0.25	3.3	4.2	0.02	4.2
	30	112	102	3.88	3.9	0.04	3.9	5.4	0.02	5.4
	31	108	102	3.07	2.9	0.37	2.5	4.0	0.03	4.0
Aug.	1	124	120	3.35	6.0	<0.01	6.0	3.8	0.02	3.8
	2	124	118	2.57	4.1	<0.01	4.1	4.3	0.03	4.3
	3	128	124	2.48	3.9	<0.01	3.9	4.4	0.04	4.4
	4	134	126	3.58	4.8	<0.01	4.8	4.8	0.02	4.8
	5	118	104	2.66	8.5	0.29	8.2	3.8	0.01	3.8
	6	117	100	2.63	7.7	0.42	7.3	3.7	0.01	3.7
	7	117	104	3.12	5.2	0.38	4.8	3.4	0.01	3.4
	8	120	109	3.26	6.3	0.75	5.5	3.4	0.01	3.4
	9	124	120	3.26	6.6	0.42	6.2	2.5	0.01	2.5
	10	116	113	3.16	6.3	<0.01	6.3	2.5	0.02	2.5
	11	124	124	3.27	4.9	<0.01	4.9	2.9	0.01	2.9
	12	117	107	4.12	4.0	<0.01	4.0	2.7	0.01	2.7
	13	103	98	3.62	4.1	0.17	3.9	3.9	0.01	3.9
	14	101	95	3.50	4.3	<0.01	4.3	2.7	0.01	2.7
	15	116	109	3.84	6.3	0.26	6.0	2.4	0.01	2.4
	16	123	115	3.89	5.0	0.23	4.8	2.4	0.00	2.4
	17	105	103	3.47	5.8	0.09	5.7	1.9	0.01	1.9
	18	103	99	4.07	6.7	0.18	6.5	2.6	0.01	2.6
	19	120	117	3.67	4.8	0.36	4.4	2.4	0.01	2.4
	20	122	120	3.62	4.2	0.09	4.1	4.3	0.01	4.3
Mean		101	92	3.15	5.7	0.26	5.4	4.5	0.03	4.5
Stan. Dev.		30	34	0.67	0.2	0.32	2.0	2.9	0.09	2.8

TABLE A-19. SUMMARY DATA SHEET, MT. SHASTA, #1 LAGOON INFLUENT (FIELD)

1978 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C	Daily Total Flow mgd
Apr. 14	206	109	103	89	31	4.8×10^5	9.5	7.5	6.8	7.0	10.0	0.790
15	73	65	90	99	33	1.6×10^5	8.4	6.9	8.0	6.9	8.0	1.180
16	24	21	89	74	35	1.35×10^5	9.3	7.3	7.7	6.9	9.0	1.080
17	27	25	79	89	39	1.35×10^5	8.4	7.1	7.3	6.9	10.0	0.957
18	88	73	78	112	37	8.85×10^5	7.8	7.1	7.0	6.8	10.5	0.887
19	131	106	78	45	39	2.7×10^5	7.8	7.3	7.1	6.9	10.0	0.932
20	70	63	76	92	40	9.0×10^5	8.3	7.1	7.2	6.9	11.0	0.854
21	91	73	77	162	43	3.8×10^5	7.9	7.3	6.9	6.9	11.5	0.813
22	47	42	78	131	43	3.8×10^5	7.3	7.1	6.9	7.0	12.0	0.806
23	38	34	81	153	47	4.25×10^5	6.5	7.2	5.8	6.9	11.5	0.775
24	49	37	84	161/155	34/34	4.5×10^5	6.8	7.0	6.7	6.8	10.5	0.877
25	91	78	79	117	30	5.9×10^5	6.7	7.0	6.3	6.8	11.0	0.946
26	54	40	79	-	-	4.55×10^5	7.5	6.9	6.8	6.9	11.5	0.938
27	55	51	81	-	-	6.15×10^5	6.5	7.2	6.6	6.9	13.0	0.874
28	50	24	85	-	-	2.9×10^5	5.7	7.0	6.1	6.9	13.0	0.868
Mean	73	56	83	110/155	38/34	5.5730 L	7.6	7.1	6.9	6.9	10.8	0.905
Stan. Dev.	46	28	7	36/0	5/0	0.2618 L	1.1	0.2	0.6	0.8	1.4	0.109

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-20. SUMMARY DATA SHEET, MT. SHASTA, #1 LAGOON INFLUENT (UWRL)

1978 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	OrgN mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Apr. 14	349	263	3.28	17.3	13.8	3.5	0.74	0.073	0.67
15	318	283	3.26	16.3	8.5	7.8	0.59	0.064	0.53
16	338	268	2.62	16.2	4.5	11.7	0.59	0.036	0.55
17	344	281	2.87	17.9	6.0	11.9	0.56	0.040	0.52
18	301	252	3.97	18.3	6.9	11.4	0.57	0.057	0.51
19	325	228	4.00	17.3	6.1	11.2	0.73	0.055	0.68
20	324	237	3.47	16.7	5.7	11.0	0.50	0.041	0.46
21	331	233	4.35	16.6	7.1	9.5	0.04	0.018	0.02
22	322	206	3.88	16.2	7.1	9.1	0.50	0.265	0.24
23	329	258	3.71	15.8	6.0	9.8	0.40	0.194	0.21
24	305	247	4.76	14.8	7.6	7.2	0.38	0.055	0.32
25	286	215	3.62	14.2	5.6	8.6	0.43	0.045	0.38
26	307	238	3.47	15.6	7.1	8.5	0.43	0.044	0.39
27	313	254	3.50	16.6	6.8	9.8	0.38	0.042	0.34
28	355	230	3.76	14.6	8.7	5.9	0.38	0.188	0.19
Mean	323	246	3.63	16.3	7.2	9.1	0.48	0.081	0.40
Stan. Dev.	19	23	0.54	1.2	2.1	2.3	0.17	0.073	0.19

TABLE A-21. SUMMARY DATA SHEET, MT. SHASTA, #2 LAGOON EFFLUENT (FIELD)

1978 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
Apr. 14	70	16	73	24	7	1730	12.1	9.0	12.4	9.3	10.0
15	34	26	72	19	6	130	11.4	8.9	11.7	9.1	5.0
16	40	27	69	22	5	1520	12.4	8.7	11.9	8.9	8.0
17	32	28	72	25	5	4225	11.6	8.7	11.3	8.8	10.0
18	32	24	68	16	6	100	11.7	8.3	10.8	8.7	11.0
19	33	28	72	18	7	250	11.4	8.3	11.9	8.7	10.0
20	35	25	69	21	5[a]	110	12.0	8.3	11.0	8.6	10.0
21	42	31	70	21	6	705	12.0	8.3	13.2	8.8	12.0
22	36	35	71	22	6	100	11.5	8.3	11.4	8.7	12.0
23	36	28	70	19	5[a]	26	10.8	8.1	10.4	8.5	13.0
24	22	10	71	18/16	3[a]/3[a]	42	11.4	8.0	12.4	8.3	11.0
25	28	16	69	15	5[a]	TNC	9.8	7.8	9.6	8.3	12.0
26	22	9	70	-	-	560	9.6	7.6	9.3	8.0	12.0
27	22	13	71	-	-	270	8.5	7.1	8.3	7.9	15.0
28	11	4	75	-	-	130	8.3	7.3	8.3	7.5	13.5
Mean	33	21	71	20/16	5/3	2.2520 L	11.0	8.2	10.9	8.5	11.0
Stan. Dev.	13	9	2	3/0	1/0	0.8765 L	1.3	0.6	1.5	0.5	2.4

[a] Outside the 40-70% limit.

TNC - Too numerous to count.

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-22. SUMMARY DATA SHEET, MT. SHASTA, #2 LAGOON EFFLUENT (UWRL)

1978 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Apr. 14	67	62	2.21	11.6	4.2	7.4	0.80	0.092	0.71
15	62	47	2.29	13.1	3.5	9.6	0.93	0.093	0.84
16	69	57	2.33	12.3	4.2	8.1	0.62	0.083	0.54
17	64	55	2.19	11.4	3.8	7.6	0.52	0.077	0.44
18	62	48	2.62	11.8	5.0	6.8	0.51	0.077	0.43
19	64	52	2.50	11.4	4.7	6.7	0.46	0.071	0.39
20	62	44	2.53	10.8	4.8	6.0	0.48	0.075	0.40
21	70	60	2.66	11.5	5.6	5.9	0.43	0.075	0.36
22	69	53	2.59	12.5	4.3	8.2	0.43	0.079	0.35
23	68	53	2.62	11.7	4.3	7.4	0.44	0.083	0.36
24	70	55	2.54	11.3	4.1	7.2	0.45	0.080	0.37
25	68	58	2.66	9.5	3.8	5.7	0.43	0.084	0.35
26	70	50	2.65	12.7	4.1	8.6	0.42	0.085	0.34
27	61	48	2.82	10.6	4.7	5.9	0.43	0.091	0.34
28	74	64	2.78	10.6	4.6	6.0	0.38	0.100	0.28
Mean	67	54	2.53	11.5	4.4	7.1	0.52	0.083	0.43
Stan. Dev.	4	6	0.19	0.9	0.5	1.2	0.15	0.008	0.15

TABLE A-23. SUMMARY DATA SHEET, MT. SHASTA, #3 FILTER EFFLUENT (FIELD)

1978 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
Apr. 14	49	13	64	9^a	7	65	9.4	7.3	7.7	7.5	10.0
15	9	2	60	8^a	4	83	9.9	7.1	9.2	7.2	7.0
16	18	10	49	7^a	4	117	10.6	6.8	9.4	7.1	7.0
17	11	10	46	5^a	5	36	9.0	6.9	6.8	7.3	10.0
18	15	9	52	8^a	4	104	8.6	7.0	5.4	7.3	10.0
19	7	2	43	8	7	52	9.1	7.0	4.6	7.3	10.0
20	10	4	54	10	6	62	7.2	7.1	3.0	7.3	10.0
21	10	9	52	8	4^a	40	6.6	7.0	4.4	7.2	11.0
22	6	3	60	8	3^a	18	6.8	7.0	4.0	7.5	11.0
23	4	2	63	9	5	54	6.5	7.0	4.4	7.1	12.0
24	4	3	54	$4^a/2^a$	$2^a/3^a$	36	7.5	6.8	4.6	7.1	11.0
25	10	7	60	5^a	2^a	10	8.1	7.0	6.1	7.1	12.0
26	4	3	54	-	-	12	9.4	6.7	7.9	6.9	11.5
27	3	1	56	-	-	22	8.7	6.9	7.3	6.7	13.5
28	4	1	53	-	-	14	8.4	6.7	7.1	6.6	14.0
Mean	11	5	55	7/2	4/3	1.5730 L	8.4	7.0	6.1	7.1	10.7
Stan. Dev.	11	4	6	2/0	2/0	0.3405 L	1.2	0.2	2.0	0.3	1.9

/ - BOD_5/BOD_5 with nitrification inhibitor.

[a] Outside the 40-70% limit.

L = Log_{10}

TABLE A-24. SUMMARY DATA SHEET, MT. SHASTA, #3 FILTER EFFLUENT (UWRL)

1978 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Apr. 14	54	47	2.06	8.3	0.04	8.3	3.15	0.070	3.08
15	52	41	2.06	9.1	0.15	9.0	2.85	0.075	2.78
16	47	39	1.79	9.4	0.23	9.2	2.45	0.030	2.42
17	51	44	2.05	8.5	0.18	8.3	2.60	0.065	2.54
18	49	39	2.07	7.7	0.30	7.4	2.80	0.120	2.68
19	44	34	1.75	7.8	0.11	7.7	2.80	0.075	2.72
20	41	37	2.07	7.5	0.74	6.8	2.65	0.24	2.41
21	63	50	1.93	8.8	0.55	8.2	2.38	0.17	2.21
22	60	40	1.93	9.2	0.87	8.3	2.40	0.25	2.15
23	58	38	1.94	8.2	1.18	7.0	2.85	0.24	2.61
24	53	39	1.82	7.6	0.51	7.1	5.55	0.08	5.47
25	59	48	1.69	7.7	0.40	7.3	7.80	0.32	7.48
26	45	40	1.75	11.3	0.22	11.1	6.35	0.07	6.28
27	51	35	1.75	9.9	0.14	9.8	6.05	0.05	6.00
28	51	36	1.88	7.0	0.04	7.0	1.90	0.023	1.88
Mean	52	40	1.90	8.5	0.38	8.1	3.6	0.125	3.51
Stan. Dev.	6	5	0.14	1.1	0.33	1.3	1.8	0.094	1.82

TABLE A-25. SUMMARY DATA SHEET, MT. SHASTA, #4 CHLORINATED FILTER EFFLUENT (FIELD)

1978 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C	Daily Total Flow mgd
Apr. 14	61	14	39	6[a]	6	20	9.5	6.9	8.7	6.9	11.0	0.313
15	12	6	33	5[a]	4[a]	9	10.4	6.6	9.3	6.9	9.0	0.374
16	11	7	35	4[a]	2[a]	5	10.7	6.4	9.6	6.8	8.0	0.526
17	6	4	30	3[a]	3[a]	4	10.0	6.8	7.3	7.0	10.0	0.774
18	13	7	36	6[a]	3[a]	11	9.4	7.0	6.9	6.7	10.0	1.005
19	10	3	33	3[a]	3[a]	12	9.7	6.7	6.4	7.3	10.0	1.038
20	9	2	38	5	3[a]	9	8.6	6.9	6.6	6.7	10.0	1.149
21	5	0	37	3[a]	2[a]	9	8.6	6.7	6.3	6.7	12.0	0.893
22	3	2	44	3[a]	3[a]	9	8.7	6.9	6.3	7.0	12.0	0.705
23	5	2	50	3[a]	3[a]	4	8.8	6.9	5.6	6.7	12.0	0.678
24	4	2	40	2[a]/2[a]	2[a]/2[a]	11	9.1	7.0	6.5	6.7	12.0	0.887
25	8	4	46	5[a]	3[a]	< 1	9.2	6.9	8.0	6.7	13.0	0.335
26	1	1	47	-	-	1.0	10.4	6.7	8.6	6.6	12.0	0.584
27	4	2	45	-	-	< 1	9.7	6.9	8.3	6.5	14.0	0.564
28	5	3	42	-	-	< 1	9.6	6.9	7.6	6.3	15.0	0.580
Mean	11	4	40	4/2	3/2	0.6789 L	9.5	6.8	7.5	6.8	11.3	0.694
Stan. Dev.	14	3	6	1/0	1/0	0.4605 L	0.7	0.2	1.2	0.2	1.9	0.261

/ - BOD_5/BOD_5 with nitrification inhibitor.

[a] Outside the 40-70% limit.

L = Log_{10}

TABLE A-26. SUMMARY DATA SHEET, MT. SHASTA, #4 CHLORINATED FILTER EFFLUENT (UWRL)

1978 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Apr. 14	30	22	1.54	3.2	0.13	3.1	3.45	0.010	3.44
15	21	18	1.54	2.9	0.21	2.7	2.35	0.010	2.34
16	26	24	1.54	3.0	0.11	2.9	2.60	0.005	2.60
17	29	26	1.64	2.9	0.15	2.8	2.45	0.005	2.44
18	26	22	1.93	2.9	0.29	2.6	2.60	0.020	2.58
19	24	21	1.62	2.8	0.08	2.7	3.30	0.020	3.28
20	24	16	1.82	2.5	0.69	1.8	2.65	0.025	2.62
21	43	27	1.84	2.8	0.53	2.3	2.44	0.004	2.44
22	36	27	1.82	2.7	0.84	1.9	2.26	0.008	2.25
23	39	23	1.79	2.6	1.18	1.4	2.85	0.020	2.83
24	31	25	1.71	2.8	0.53	2.3	5.20	0.010	5.19
25	33	27	1.65	2.9	0.36	2.5	7.40	0.020	7.38
26	28	27	1.60	2.7	0.22	2.5	3.95	0.040	3.91
27	32	24	1.69	2.2	0.06	2.1	6.60	0.010	6.59
28	30	21	1.76	2.8	0.05	2.8	1.88	0.008	1.87
Mean	30	23	1.70	2.8	0.36	2.4	3.47	0.014	3.45
Stan. Dev.	6	3	0.12	0.2	0.33	0.5	1.66	0.010	1.65

TABLE A-27. SUMMARY DATA SHEET, MORIARTY, #1 LAGOON INFLUENT (FIELD)

1977 Date		SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C	Daily Total Flow mgd
May	19	162	128	404	62	46	3.95×10^6	1.7	7.9	1.5	8.0	13.0	I.F.
	20	183	152	421	102^a	72	4.15×10^6	2.0	7.9	0.8	7.7	17.5	I.F.
	21	216	167	424	132^a	62	9.65×10^6	1.8	8.1	0.8	7.9	18.0	I.F.
	22	170	128	409	106	108^a	4.1×10^6	2.0	8.3	0.3	7.8	18.0	I.F.
	23	134	111	424	96^a	73	4.35×10^6	0.9	8.3	0.1	7.8	20.0	I.F.
	24	148	112	438	136	82	3.35×10^6	3.6	8.2	0.7	8.2	19.0	I.F.
	25	82	62	432	165	86	3.25×10^6	2.5	8.1	2.2	8.0	17.0	I.F.
	26	228	192	433	106	69	3.85×10^6	3.3	8.1	2.2	8.0	18.0	I.F.
	27	141	94	429	129^a	85^a	1.45×10^6	2.7	8.1	1.2	8.0	21.0	I.F.
	28	142	74	422	86	34	20×10^6	2.7	8.1	1.2	7.9	22.5	I.F.
	29	148	134	431	105/79	79/74	8.05×10^6	1.8	8.1	2.3	7.9	22.5	I.F.
	30	106	88	416	95	66	3.75×10^6	0.8	8.1	0.2	7.9	23.0	I.F.
	31	158	122	413	168	89^a	4×10^6	2.3	8.1	0.1	7.9	21.0	I.F.
June	1	160	130	417	182	120^a	6.85×10^6	1.3	8.1	0.1	7.9	21.0	I.F.
	2	468	434	443	244^a	124^a	5×10^4	1.7	8.1	0.3	7.9	22.0	I.F.
	3	140	102	437	128	64^a	8.25×10^6	1.2	8.1	0.1	7.9	26.0	I.F.
	4	188	148	437	137	126^a	8.2×10^6	2.4	8.1	1.8	7.9	21.5	I.F.
	5	142	116	441	192	112^a	8.2×10^6	2.0	8.1	0.3	7.9	24.5	I.F.
	6	128	92	442	125	67^a	8.35×10^6	1.4	8.2	0.9	8.0	20.0	I.F.
	7	118	102	433	89	89	17.5×10^6	0.5	8.1	0.5	8.1	21.0	I.F.
	8	178	136	425	110/134	114/110	7×10^6	0.7	8.1	0.5	7.9	23.0	I.F.
	9	138	108	428	92	59	10×10^6	1.1	8.0	0.1	7.9	24.0	I.F.
	10	264	218	407	101^a	51	21×10^6	0.7	7.9	0.1	7.9	22.5	I.F.
	11	202	166	441	113	61	17×10^6	0.6	7.9	0.1	7.8	22.0	0.046*
	12	172	128	443	163	93	11.5×10^6	1.5	8.1	0.1	7.9	24.5	0.035*
	13	148	108	440	230^a	139^a	12×10^6	1.6	8.0	0.3	7.9	23.0	0.031*
	14	186	150	444	167	78	10.5×10^6	0.7	8.0	0.2	7.9	24.5	0.032*
	15	222	190	439	110^a	43^a	14×10^6	0.5	8.0	0.1	7.7	26.0	0.035*
	16	208	178	432	186	70	9.5×10^6	0.5	7.9	1.0	7.8	26.0	0.031*
	17	142	18	407	136	57	17.5×10^6	1.6	8.1	0.3	7.9	23.0	0.040*
Mean		174	136	428	133/107	81/92	6.5990 L	1.6	8.1	0.7	7.9	21.5	0.035
Stan. Dev.		68	70	12	43/39	27/25	0.1242 L	0.8	0.1	0.7	0.1	3.0	0.004

[a] Outside 40-70% depletion range.

/ - BOD_5/BOD_5 with nitrification inhibitor.

I.F. - Inoperative flow meter.

Log = Log_{10}

*Uncalibrated flow meter

TABLE A-28. SUMMARY DATA SHEET, MORIARTY, #1 LAGOON INFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
May 19	310	149	7.86	40	40	0	0.04	0.024	0.02
20	361	138	4.10	42	42	0	--	0.026	--
21	501	142	4.82	46	40	6	--	0.022	--
22	321	152	4.06	42	37	5	--	0.040	--
23	371	152	4.40	46	43	3	--	0.033	--
24	364	185	4.10	43	46	0	0.02	0.027	0.00
25	292	181	4.06	42	48	0	0.02	0.027	0.00
26	353	174	4.03	49	45	4	0.02	0.028	0.00
27	368	170	7.95	49	36	13	0.02	0.029	0.00
28	343	152	8.61	42	43	0	0.03	0.027	0.00
29	321	192	8.69	41	40	1	0.04	0.041	0.00
30	285	109	7.48	40	41	0	0.02	0.024	0.00
31	310	174	8.89	38	42	0	0.03	0.033	0.00
June 1	490	152	9.14	35	31	4	0.10	0.046	0.05
2	427	213	9.67	42	41	1	0.03	0.046	0.00
3	358	179	10.89	45	36	9	0.02	0.029	0.00
4	555	184	14.21	44	34	10	0.02	0.027	0.00
5	395	182	10.62	38	35	3	0.03	0.035	0.00
6	343	162	10.17	42	36	6	0.02	0.028	0.00
7	284	124	8.97	44	30	14	0.02	0.035	0.00
8	362	163	11.40	42	24	18	0.00	0.027	0.00
9	339	163	9.75	46	29	17	0.03	0.031	0.00
10	517	137	11.84	53	34	19	0.01	0.024	0.00
11	300	172	11.43	52	39	13	0.02	0.024	0.00
12	225	179	--	50	38	12	0.04	0.025	0.02
13	354	162	10.48	40	31	9	0.03	0.025	0.00
14	409	240	11.43	42	36	6	0.04	0.036	0.00
15	456	172	11.20	54	37	17	0.02	0.033	0.00
16	416	153	12.55	50	36	14	0.02	0.036	0.00
17	338	213	12.75	50	36	14	0.03	0.032	0.00
Mean	369	167	8.81	44	38	9	0.03	0.031	0.03
Stan. Dev.	75	27	3.04	5	5	6	0.02	0.064	0.02

TABLE A-29. SUMMARY DATA SHEET, MORIARTY, #2 LAGOON EFFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
May 19	93	70	248	25	10	5	9.4	9.1	11.3	9.3	13.0
20	64	59	223	25	14[a]	1	11.8	9.2	11.7	9.2	17.5
21	55	34	218	25	15[a]	31	9.9	9.2	11.2	9.3	15.0
22	56	50	210	25	16	4	9.6	9.2	10.0	9.3	16.0
23	42	36	195	21	12	6	10.2	9.3	11.3	9.4	18.0
24	73	62	202	37	17	8	9.6	9.2	9.3	9.3	18.5
25	42	36	191	29	26	13	8.3	9.1	8.8	9.3	15.0
26	50	48	188	29	21	11	8.7	9.1	8.7	9.3	17.0
27	48	21	201	49[a]	30[a]	10	8.7	9.1	8.2	9.3	18.5
28	47	26	208	19	12	13	8.4	9.1	6.8	9.1	18.0
29	227	219	224	67[a]/186	42[a]/42[a]	21	3.9	8.9	3.1	8.9	21.5
30	146	142	239	86[a]	39[a]	2	2.0	8.4	1.3	8.8	21.5
31	42	36	249	37	28[a]	4	4.4	8.7	2.7	8.8	20.5
June 1	34	33	258	67[a]	29[a]	42	5.7	8.6	3.4	8.6	20.0
2	50	39	267	38[a]	31[a]	25	6.3	8.6	5.2	8.5	22.5
3	40	29	270	18	16	14	6.5	8.6	5.7	8.6	23.0
4	43	42	266	21	27[a]	63	8.3	8.7	8.6	8.7	21.0
5	53	42	282	36	27[a]	63	9.5	8.9	10.6	8.9	23.0
6	73	51	282	27[a]	16[a]	3	9.9	9.1	10.5	9.1	20.0
7	164	136	278	14	21	56	7.6	9.1	9.3	9.3	21.0
8	92	75	269	28/26	36/35	84	8.6	9.1	9.0	9.1	23.0
9	86	66	298	26	52	100	8.1	8.8	8.6	8.9	23.5
10	94	79	267	20[a]	19	132	9.4	8.5	8.3	8.7	22.0
11	150	118	295	43	14	144	5.7	8.7	3.8	8.9	22.5
12	142	108	296	76[a]	26	238	4.5	8.5	6.5	8.7	23.5
13	122	102	291	62[a]	40[a]	120	5.7	8.6	6.0	8.7	23.0
14	88	70	307	25	34	190	6.4	8.7	5.7	8.7	23.0
15	90	56	322	30[a]	21[a]	150	6.3	8.5	6.4	8.5	24.0
16	80	58	317	30	23	316	6.5	8.3	6.9	8.5	25.0
17	112	14	338	26	22	282	7.4	8.5	6.9	8.5	23.0
Mean	83	65	257	35/106	25/39	1.4340 L	7.6	8.8	7.5	8.9	20.4
Stan. Dev.	46	44	43	18/113	10/5	0.7006 L	2.2	0.3	2.8	0.3	3.1

[a] Outside 40-70% depletion range.

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-30. SUMMARY DATA SHEET, MORIARTY, #2 LAGOON EFFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
May 19	142	97	1.35	13.1	7.10	6.0	0.03	0.043	0.00
20	144	97	0.80	13.7	5.63	8.1	--	0.044	--
21	151	93	0.85	14.4	5.31	9.1	–	0.051	--
22	143	92	0.77	14.1	5.20	8.9	--	0.056	–
23	131	93	0.79	14.1	6.13	8.0	0.03	0.068	0.00
24	135	106	0.80	14.2	5.46	8.7	0.07	0.073	0.00
25	188	109	0.89	13.7	4.79	8.9	0.05	0.077	0.00
26	171	114	0.90	9.1	5.50	3.6	0.06	0.078	0.00
27	149	111	1.55	14.7	5.29	9.4	0.06	0.068	0.00
28	132	115	1.65	13.8	6.29	7.5	0.11	0.092	0.02
29	180	118	1.94	38	7.29	3.1	0.11	0.092	0.02
30	148	138	2.93	32	8.76	2.3	0.09	0.108	0.00
31	140	123	3.18	14.6	8.10	6.5	0.09	0.089	0.00
June 1	155	115	2.39	15.3	8.64	6.7	0.09	0.070	0.02
2	134	113	2.96	15.7	8.72	7.0	0.10	0.084	0.02
3	89	64	2.78	15.9	9.21	6.7	0.13	0.126	0.00
4	139	104	2.88	15.4	8.88	6.5	0.17	0.167	0.00
5	141	123	2.84	15.3	8.14	7.2	0.27	0.26	0.01
6	155	114	3.12	13.9	6.99	6.9	0.32	0.32	0.00
7	151	84	2.95	14.4	6.33	8.1	0.33	0.35	0.00
8	148	109	--	14.0	5.78	8.2	0.33	0.37	0.00
9	147	107	3.45	16.2	5.66	10.6	0.37	0.45	0.00
10	157	116	4.18	17.4	7.34	10.1	0.40	0.47	0.00
11	149	121	--	14.6	6.09	8.5	0.44	0.49	0.00
12	140	127	5.03	14.1	6.21	7.9	0.44	0.52	0.00
13	140	121	4.62	17.2	8.83	8.4	0.38	0.53	0.00
14	135	111	4.39	13.1	7.98	5.1	0.38	0.64	0.00
15	135	132	4.60	16.5	8.07	8.4	0.29	0.59	0.00
16	149	109	3.81	14.1	8.30	5.8	0.30	0.61	0.00
17	93	88	4.12	15.8	8.39	7.4	0.37	0.57	0.00
Mean	144	109	2.59	15.5	7.02	7.3	0.22	0.252	0.02
Stan. Dev.	19	15	1.38	6.1	1.39	1.9	0.15	0.214	0.01

TABLE A-31. SUMMARY DATA SHEET, MORIARTY, #3 CHLORINATED LAGOON EFFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C	Daily Total Flow mgd[f]
May 19	80	53	261	27	12	< 1	8.8	9.1	8.0	9.2	13.0	0.036
20	50	47	246	26	16[a]	< 1	9.8	9.3	9.3	9.2	18.0	0.036
21	33	26	230	19	20[a]	< 1	8.3	9.2	8.5	9.2	15.5	0.043
22	46	36	219	26	16	< 1	7.8	9.1	8.2	9.2	16.0	0.043
23	37	34	220	18	18[a]	< 1	7.8	9.3	8.3	9.3	17.0	0.043
24	42	36	217	24	22	< 1	8.5	9.2	7.8	9.3	18.0	0.036
25	26	23	202	27	24	2	7.9	9.1	7.3	9.1	16.0	0.036
26	35	34	195	18	17	7	7.9	9.0	7.1	9.1	17.0	0.036
27	39	2	212	33[a]	30[a]	1	8.4	9.1	7.7	9.1	18.0	0.029
28	46	32	210	16[a]	18	< 1	8.6	9.1	7.5	9.1	18.0	0.029
29	46	45	226	74[a]/52	43[a]/42[a]	1	6.3	9.1	0.6	8.5	21.0	0.029
30	224	110	256	44[a]	46[a]	1	4.2	8.3	1.0	8.3	22.5	0.029
31	109	101	260	85[a]	42[a]	64	5.3	8.4	4.6	8.5	21.0	0.043
June 1	46	42	281	95[a]	45[a]	7	5.9	8.5	3.9	8.5	20.0	0.043
2	40	32	272	58[a]	34[a]	1	6.7	8.6	4.7	8.5	21.0	0.036
3	31	25	272	29	19	3	7.0	8.6	5.2	8.5	24.0	0.043
4	34	33	277	27	44[a]	2	7.6	8.7	6.3	8.7	24.0	0.043
5	42	30	276	25	29[a]	4	8.1	8.8	6.8	8.7	20.5	0.043
6	56	41	280	21[a]	22	< 1	8.5	9.1	7.1	8.9	20.0	0.036
7	70	53	283	17[a]	32	6	7.5	9.1	7.8	9.3	21.0	0.036
8	82	68	267	30/34	39/41	2	8.1	9.0	6.9	8.9	23.0	0.043
9	77	65	301	24	62[a]	< 1	7.6	8.8	6.5	8.7	24.0	0.043
10	78	58	279	25	37	< 1	7.1	8.6	8.5	8.5	22.0	0.043
11	88	86	306	33[a]	20	< 1	7.0	8.7	5.9	8.6	23.0	0.036
12	126	98	304	67[a]	41	< 1	6.2	8.6	3.2	8.3	22.0	0.036
13	132	106	316	73[a]	55[a]	3	6.3	8.5	3.5	8.4	23.0	0.036
14	70	46	309	54[a]	40	8	5.3	8.5	3.9	8.5	24.0	0.036
15	80	54	318	28[a]	28[a]	< 1	7.3	8.5	5.1	8.5	24.0	0.036
16	74	52	314	31	24	< 1	7.4	8.5	5.0	8.3	25.0	0.043
17	88	54	343	26	25	< 1	7.5	8.6	5.2	8.5	21.5	0.036
Mean	68	51	265	37/43	31/41	0.2546 L	7.4	8.8	6.0	8.8	20.4	0.038
Stan. Dev.	41	26	40	22/13	13/1	0.4258 L	1.2	0.3	2.2	0.3	0.3	0.005

[a] Outside 40-70% depletion range.

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

[f] Flow obtained by daily weir readings.

TABLE A-32. SUMMARY DATA SHEET, MORIARTY, #3 CHLORINATED LAGOON EFFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
May 19	136	102	1.41	13.1	6.24	6.9	0.10	0.035	0.06
20	144	102	1.00	14.0	5.55	8.4	0.04	0.038	0.00
21	140	99	0.85	13.4	5.24	8.2	0.05	0.056	0.00
22	140	104	1.07	18.1	5.12	13.0	0.05	0.051	0.00
23	142	108	0.80	13.3	6.25	7.0	0.08	0.073	0.01
24	145	115	0.90	13.1	5.55	7.5	0.08	0.079	0.00
25	175	131	1.04	14.4	4.88	9.5	0.10	0.079	0.02
26	150	122	1.00	12.2	5.37	6.8	0.08	0.081	0.00
27	156	116	1.65	13.0	4.88	8.1	0.10	0.073	0.03
28	125	124	1.89	13.9	5.95	7.9	0.11	0.091	0.02
29	181	129	1.94	17.2	6.33	10.9	0.09	0.092	0.00
30	115	81	3.38	39	12.8	26	0.03	0.027	0.00
31	106	94	3.54	24	13.4	11	0.02	0.035	0.00
June 1	198	141	3.00	21	12.9	8	0.07	0.021	0.05
2	150	133	2.63	18.9	10.3	8.6	0.04	0.054	0.00
3	147	74	2.71	17.4	9.83	7.6	0.11	0.053	0.06
4	153	123	2.77	16.8	8.97	7.8	0.11	0.059	0.05
5	150	91	2.77	15.5	8.68	6.8	0.09	0.060	0.03
6	148	122	2.93	14.7	7.30	7.4	0.09	0.089	0.00
7	147	110	3.18	13.2	8.12	5.1	0.08	0.083	0.00
8	142	120	3.23	9.9	6.25	3.6	0.08	0.098	0.00
9	136	120	3.34	13.4	6.21	7.2	0.11	0.113	0.00
10	162	132	3.91	14.4	6.48	7.9	0.05	0.060	0.00
11	150	140	4.44	12.9	7.34	5.6	0.20	0.035	0.16
12	147	117	4.80	11.4	8.28	3.1	0.19	0.042	0.15
13	131	89	5.22	12.8	6.88	5.9	0.20	0.039	0.16
14	130	62	4.47	12.9	11.2	1.7	0.14	0.033	0.11
15	126	124	4.61	12.9	7.98	4.9	0.14	0.035	0.10
16	140	85	3.96	12.1	7.75	4.4	0.13	0.032	0.10
17	85	78	4.07	10.3	8.12	2.2	0.16	0.035	0.12
Mean	143	110	2.75	15.3	7.67	7.6	0.10	0.058	0.08
Stan. Dev.	21	21	1.35	5.4	2.43	4.3	0.05	0.025	0.05

TABLE A-33. SUMMARY DATA SHEET, MORIARTY, #4 FILTER EFFLUENT (FIELD)

1977		SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
May	19[b]	14	1	249	10	7	1	7.3	7.9	7.8	7.8	13.0
	20	15	12	241	19[a]	11[a]	10	7.9	8.1	6.6	7.5	16.5
	21	5	3	221	17[a]	11[a]	3	8.1	8.1	no flow		
	22	11	4	201	12[a]	12[a]	19	8.1	8.5	no flow		
	23	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
	24	16	4	128	19[a]	23[a]	< 1	8.4	8.3	7.4	8.5	19.0
	25	6	4	127	17	24[a]	6	8.2	8.5	no flow		
	26	11	9	135	19	18	2	8.0	8.4	no flow		
	27	13	2	153	26[a]	31[a]	15	7.7	8.5	7.2	8.3	19.0
	28	31	17	156	12[a]	14	TNTC	7.5	8.5	no flow		
	29	31	30	176	16/16	34[a]/33[a]	TNTC	6.5	8.3	6.4	8.3	22.0
	30	30	22	256	29[a]	38[a]	TNTC	4.2	8.1	4.3	8.2	23.0
	31	26	22	310	30[a]	31[a]	7	2.7	8.1	no flow		
June	1	32	31	340	26	28	84	4.3	8.1	no flow		
	2	19	12	329	33[a]	22	49	7.4	8.2	6.5	8.0	22.0
	3	6	2	296	15	11	TNTC	7.2	8.2	no flow		
	4	11	10	275	9	27	TNTC	7.1	8.1	no flow		
	5	15	11	267	16	23	TNTC	7.6	8.2	no flow		
	6	11	8	265	7[a]	12[a]	< 1	7.5	8.3	no flow		
	7	10	9	250	7[a]	22	32	6.9	8.2	6.7	8.2	21.0
	8	21	14	249	11/12	21/19	< 1	7.0	8.3	no flow		
	9	18	12	246	14	22	82	6.8	8.1	no flow		
	10	8	5	242	22[a]	18	< 1	7.1	8.6	no flow		
	11	9	5	282	23[a]	14	7100	7.0	8.7	5.7	7.8	23.5
	12	11	7	306	18	18	150	6.2	8.6	no flow		
	13	19	12	303	24[a]	39[a]	7400	6.3	8.5	4.7	7.8	24.0
	14	32	22	309	32[a]	23	< 1	5.3	8.5	no flow		
	15	190	110	383	60[a]	23[a]	< 1	7.3	8.5	no flow		
	16	31	18	207	18	17	360	7.4	8.5	no flow		
	17	17	6	220	17	22	80	7.5	8.6	no flow		
Mean		23	15	246	20/14	21/26	0.9082 L	6.9	8.3	6.3	8.0	20.3
Stan. Dev.		33	20	66	11/3	8/10	1.1460 L	1.3	0.2	1.1	0.3	3.5

[a] Outside 40-70% depletion range.

[b] arrived three weeks late.

/ - BOD_5/BOD_5 with nitrification inhibitor.

N.S. - No sample.

TNTC - Too numerous to count.

L = Log_{10}

TABLE A-34. SUMMARY DATA SHEET, MORIARTY, #4 FILTER EFFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
May 19[a]	74	68	3.23	13.1	14.7	0.0	2.79	2.11	0.68
20	78	66	1.81	14.4	10.8	3.6	2.32	2.33	0.00
21	55	52	1.47	12.5	10.0	2.5	2.42	2.22	0.20
22	75	71	0.64	8.3	5.67	2.6	0.33	0.260	0.07
23	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
24	92	85	0.44	4.2	1.63	2.6	0.18	0.101	0.08
25	92	84	0.54	4.1	0.50	3.6	0.18	0.093	0.09
26	89	74	0.55	6.9	1.69	5.2	0.17	0.088	0.08
27	117	103	0.94	7.6	0.99	6.6	0.18	0.088	0.09
28	75	51	1.06	8.5	1.00	7.5	0.25	0.216	0.03
29	98	96	1.70	8.3	3.86	4.4	1.11	1.16	0.00
30	126	111	1.40	8.6	2.52	6.1	0.30	0.268	0.03
31	132	110	1.57	8.6	2.67	5.9	0.42	0.470	0.00
June 1	129	108	1.99	9.9	3.34	6.6	0.47	0.450	0.02
2	108	95	2.15	8.5	4.01	4.5	--	0.560	–
3	92	84	2.29	8.1	4.63	3.5	--	0.560	–
4	96	81	2.10	13.6	5.95	7.6	--	1.02	–
5	68	44	2.10	10.1	6.57	3.5	1.28	1.36	0.00
6	91	87	2.22	11.1	6.99	4.1	0.77	0.870	0.00
7	88	85	1.94	11.2	8.83	2.4	0.68	0.740	0.00
8	96	80	1.91	11.7	9.88	1.8	1.00	1.24	0.00
9	86	85	1.94	10.9	10.0	0.9	2.20	2.35	0.00
10	87	47	1.82	12.0	6.95	5.0	--	3.19	–
11	87	83	1.93	11.8	7.42	4.4	2.13	2.09	0.04
12	84	77	2.78	8.5	7.81	0.7	2.29	2.16	0.13
13	120	66	2.50	8.4	4.69	3.7	1.99	2.19	0.00
14	90	67	2.81	8.7	3.90	4.8	2.67	2.20	0.47
15	95	80	5.85	9.1	2.11	7.0	1.76	2.11	0.00
16	101	62	2.29	8.6	1.65	7.0	1.54	2.14	0.00
17	84	74	2.22	8.9	4.17	4.7	1.57	2.26	0.00
Mean	93	78	1.94	9.5	5.34	4.4	1.24	1.272	0.15
Stan. Dev.	18	18	1.03	2.4	3.54	1.9	0.91	0.940	0.19

N.S. - No sample.

[a] Arrived three weeks late.

TABLE A-35. SUMMARY DATA SHEET, MORIARTY, #1 LAGOON INFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C	Daily Total Flow mgd
Nov. 14	145	107	464	180	74	10.15×10^6	4.9	8.2	2.5	8.1	14.0	-
15	160	124	461	131	83	10.25×10^6	5.3	8.1	3.4	7.9	14.5	0.091
16	120	102	466	168	81	9.15×10^6	0.7	8.3	1.3	8.0	14.0	0.089
17	122	90	457	321	62	8.65×10^6	0.9	8.2	2.1	8.1	15.0	0.083
18	86	68	432	81	43	7.8×10^6	5.0	8.3	4.1	8.1	15.0	0.086
19	188	152	473	136	62	5.85×10^6	0.8	8.3	4.4	8.1	14.0	0.083
20	166	112	451	104	77	6.1×10^6	0.8	8.1	3.7	8.1	11.0	0.086
21	142	102	449	121	63	6.3×10^6	5.6	8.2	4.5	8.1	13.0	0.090
22	70	64	428	110	45	7.2×10^6	1.0	8.1	0.5	8.1	10.5	0.093
23	148	114	463	98	57	7.15×10^6	1.9	8.1	4.5	8.0	11.0	0.091
24	116	102	438	153	100	5.85×10^6	3.0	8.2	3.3	8.0	13.5	0.093
25	120	98	442	103	52	6.25×10^6	1.5	8.1	0.5	8.1	13.5	0.080
26	178	124	453	127	86	5.40×10^6	0.8	8.2	3.9	8.0	15.0	0.086
27	114	104	447	120	111	4.8×10^6	1.5	8.1	0.3	8.0	13.0	0.087
28	210	184	425	155/158	33/35	4.5×10^6	2.7	8.1	4.0	8.2	8.0	0.097
29	110	94	467	117	49	9.1×10^6	3.8	8.2	6.0	8.1	7.5	0.085
30	156	136	425	141	55	9.6×10^6	2.0	8.1	3.2	8.0	11.0	0.093
Dec. 1	124	74	407	290	45	5.35×10^6	4.1	8.1	6.0	8.1	8.0	0.100
2	196	102	400	104	25	5.1×10^6	5.1	8.3	4.3	8.0	11.5	0.102
3	78	60	382	199	40	5.75×10^6	1.4	8.1	5.1	8.1	12.0	0.092
4	144	84	423	207	75	6.65×10^6	1.1	8.2	2.7	7.9	12.0	0.097
5	120	90	389	149/125	81/61	6.55×10^6	2.5	8.3	3.0	8.1	11.0	0.101
6	92	72	382	94	63	7.4×10^6	-	8.2	-	8.1	12.0	0.090
7	90	64	414	101	32	6.3×10^6	4.3	8.3	1.7	8.0	15.0	0.097
8	82	10	409	89	26	7.4×10^6	2.6	8.1	0.0	7.9	13.0	0.098
9	134	72	407	74	29	6.25×10^6	2.5	8.3	0.0	8.0	12.5	0.096
10	112	26	414	79	33	6.20×10^6	4.5	8.3	3.3	7.9	10.0	0.099
11	32	24	418	69	120	5.7×10^6	5.8	8.3	3.5	7.9	13.0	0.092
12	132	126	388	90	43	6.85×10^6	5.2	8.2	1.7	8.1	12.0	0.107
13	150	58	398	-	-	6.65×10^6	5.1	8.2	3.4	8.0	15.0	0.097
Mean	128	94	429	135/141	58/48	6.8270 L	3.0	8.2	3.2	8.0	12.3	0.092
Stan. Dev.	39	41	28	59/25	26/18	0.0937 L	1.8	0.1	1.6	0.1	2.1	0.006

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-36. SUMMARY DATA SHEET, MORIARTY, #1 LAGOON INFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Nov. 14	245	189	10.93	50	36	14	0.03	0.005	0.03
15	251	197	10.90	66	63	3	0.02	0.004	0.02
16	261	219	11.34	53	50	3	0.04	0.006	0.03
17	207	173	10.29	46	37	9	0.05	0.010	0.04
18	157	87	9.10	43	35	8	0.05	0.008	0.04
19	189	115	10.74	43	41	2	0.07	0.007	0.06
20	223	179	10.42	40	37	3	0.05	0.005	0.05
21	259	179	10.38	53	51	2	0.07	0.006	0.06
22	247	205	9.87	43	35	8	0.08	0.019	0.06
23	267	217	11.06	43	41	2	0.08	0.014	0.07
24	197	115	9.62	41	39	2	0.10	0.025	0.08
25	268	211	8.62	38	32	6	0.10	0.033	0.07
26	303	240	10.38	44	40	4	0.08	0.026	0.05
27	281	225	9.65	42	35	7	0.06	0.009	0.05
28	328	262	10.83	48	47	1	0.16	0.071	0.09
29	293	238	9.23	37	32	5	0.07	0.008	0.06
30	272	201	8.91	49	47	2	0.03	0.020	0.01
Dec. 1	350	300	9.71	38	32	6	0.10	0.058	0.04
2	330	267	10.29	37	34	3	0.59	0.46	0.13
3	342	275	10.14	55	52	3	0.26	0.174	0.09
4	348	305	10.43	56	54	2	0.09	0.046	0.04
5	296	251	12.53	45	41	4	0.21	0.130	0.08
6	305	257	10.26	72	70	2	0.18	0.114	0.07
7	311	280	10.12	45	41	4	0.25	0.162	0.09
8	315	265	9.68	76	72	4	0.35	0.25	0.10
9	292	223	9.62	38	36	2	0.29	0.194	0.10
10	263	221	10.54	36	35	1	0.40	0.28	0.12
11	223	182	10.64	32	30	2	0.76	0.54	0.22
12	238	207	10.92	30	27	3	0.43	0.35	0.08
13	221	194	9.81	45	42	3	0.02	0.004	0.02
Mean	269	216	10.23	46	42	4	0.17	0.101	0.07
Stan. Dev.	49	52	0.79	11	11	3	0.18	0.144	0.04

TABLE A-37. SUMMARY DATA SHEET, MORIARTY, #2 LAGOON EFFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
Nov. 14	71	57	274	25	10	200	11.4	8.9	10.5	8.9	10.0
15	78	57	273	19	15	213	10.8	8.9	10.5	8.7	10.0
16	72	60	271	20	12	286	8.8	8.8	11.3	8.7	9.5
17	65	52	290	17	9	197	11.2	8.9	12.1	8.8	8.0
18	78	60	290	22	8	578	12.0	8.9	13.2	8.8	10.5
19	85	77	263	22	11	800	11.0	8.9	10.5	8.8	10.0
20	116	101	300	15	4	880	9.9	8.7	12.4	8.7	9.5
21	84	61	270	23	6	1030	10.6	8.8	11.8	8.7	8.0
22	79	64	279	17	15	1160	11.2	8.7	11.0	8.7	9.0
23	97	77	275	16	6	1040	11.5	8.7	11.6	9.0	8.0
24	80	71	267	22	.	810	11.1	8.7	12.7	9.0	7.0
25	90	69	262	20	7	250	11.3	8.7	13.0	9.0	7.0
26	94	71	273	21	7	300	10.2	8.8	11.0	9.0	9.5
27	100	85	260	21	6	250	10.2	8.5	12.0	9.0	10.0
28	100	78	267	18/117	5/6	560	11.0	8.8	11.5	9.1	9.0
29	88	77	263	30	10	390	11.2	8.7	13.6	9.1	7.0
30	91	84	261	23	.	680	10.2	8.7	13.0	9.0	6.5
Dec. 1	87	75	257	23	9	1180	11.7	8.9	12.9	8.9	7.0
2	81	77	268	21	7	1620	10.2	8.7	11.5	8.8	3.5
3	80	66	269	40	5	1690	10.1	8.7	11.4	8.9	6.5
4	100	81	270	24	17	1930	9.5	8.7	10.4	8.7	7.5
5	98	79	279	25/29	10/9	1810	9.5	8.6	10.3	8.9	8.5
6	94	77	283	41	13	1380	.	8.6	.	8.9	7.5
7	96	82	285	21	8	1400	8.9	8.7	14.4	8.9	8.0
8	100	64	285	17	4	2030	8.6	8.7	13.4	8.9	7.0
9	98	63	290	18	6	2000	9.5	8.7	14.4	8.9	7.0
10	110	26	313	18	7	2030	12.2	8.7	10.7	8.9	7.0
11	113	109	288	20	8	1380	12.4	8.7	12.3	8.8	6.5
12	46	42	296	16	8	1020	10.7	8.7	12.0	8.8	8.0
13	101	65	296	–	.	900	10.5	8.6	11.2	8.7	7.5
Mean	89	70	277	22/38	9/8	2.8930 L	10.6	8.7	12.0	8.9	8.0
Stan. Dev.	15	16	14	6/13	3/2	0.3384 L	1.0	0.1	1.2	0.1	1.5

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-37. SUMMARY DATA SHEET, MORIARTY, #2 LAGOON EFFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
Nov. 14	71	57	274	25	10	200	11.4	8.9	10.5	8.9	10.0
15	78	57	273	19	15	213	10.8	8.9	10.5	8.7	10.0
16	72	60	271	20	12	286	8.8	8.8	11.3	8.7	9.5
17	65	52	290	17	9	197	11.2	8.9	12.1	8.8	8.0
18	78	60	290	22	8	578	12.0	8.9	13.2	8.8	10.5
19	85	77	263	22	11	800	11.0	8.9	10.5	8.8	10.0
20	116	101	300	15	4	880	9.9	8.7	12.4	8.7	9.5
21	84	61	270	23	6	1030	10.6	8.8	11.8	8.7	8.0
22	79	64	279	17	15	1160	11.2	8.7	11.0	8.7	9.0
23	97	77	275	16	6	1040	11.5	8.7	11.6	9.0	8.0
24	80	71	267	22	-	810	11.1	8.7	12.7	9.0	7.0
25	90	69	262	20	7	250	11.3	8.7	13.0	9.0	7.0
26	94	71	273	21	7	300	10.2	8.8	11.0	9.0	9.5
27	100	85	260	21	6	250	10.2	8.5	12.0	9.0	10.0
28	100	78	267	18/117	5/6	560	11.0	8.8	11.5	9.1	9.0
29	88	77	263	30	10	390	11.2	8.7	13.6	9.1	7.0
30	91	84	261	23	-	680	10.2	8.7	13.0	9.0	6.5
Dec. 1	87	75	257	23	9	1180	11.7	8.9	12.9	8.9	7.0
2	81	77	268	21	7	1620	10.2	8.7	11.5	8.8	3.5
3	80	66	269	40	5	1690	10.1	8.7	11.4	8.9	6.5
4	100	81	270	24	17	1930	9.5	8.7	10.4	8.7	7.5
5	98	79	279	25/29	10/9	1810	9.5	8.6	10.3	8.9	8.5
6	94	77	283	41	13	1380	-	8.6	-	8.9	7.5
7	96	82	285	21	8	1400	8.9	8.7	14.4	8.9	8.0
8	100	64	285	17	4	2030	8.6	8.7	13.4	8.9	7.0
9	98	63	290	18	6	2000	9.5	8.7	14.4	8.9	7.0
10	110	26	313	18	7	2030	12.2	8.7	10.7	8.9	7.0
11	113	109	288	20	8	1380	12.4	8.7	12.3	8.8	6.5
12	46	42	296	16	8	1020	10.7	8.7	12.0	8.8	8.0
13	101	65	296	–	-	900	10.5	8.6	11.2	8.7	7.5
Mean	89	70	277	22/38	9/8	2.8930 L	10.6	8.7	12.0	8.9	8.0
Stan. Dev.	15	16	14	6/13	3/2	0.3384 L	1.0	0.1	1.2	0.1	1.5

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-38. SUMMARY DATA SHEET, MORIARTY, #2 LAGOON EFFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Nov. 14	68	60	4.19	18.6	11.0	7.6	0.12	0.048	0.07
15	59	53	4.32	21.9	18.7	3.2	0.14	0.050	0.09
16	62	53	4.21	14.6	11.9	2.7	0.16	0.052	0.11
17	62	58	4.18	16.9	12.5	4.4	0.18	0.052	0.13
18	59	50	4.18	17.4	15.8	1.6	0.16	0.045	0.12
19	57	53	4.27	15.3	13.8	1.5	0.23	0.056	0.17
20	65	58	4.59	17.1	15.6	1.5	0.17	0.060	0.11
21	61	55	4.37	13.9	11.6	2.3	0.17	0.058	0.11
22	58	53	4.18	18.1	15.6	2.5	0.18	0.059	0.12
23	62	58	4.35	16.6	14.2	2.4	0.19	0.062	0.13
24	60	53	4.34	16.9	14.7	2.2	0.19	0.065	0.13
25	65	53	3.82	15.6	13.2	2.4	0.18	0.068	0.11
26	68	55	4.15	18.9	16.5	2.4	0.18	0.067	0.11
27	70	62	4.09	16.1	14.2	1.9	0.20	0.070	0.13
28	67	59	4.33	19.2	17.5	1.7	0.21	0.071	0.14
29	69	61	4.07	16.1	14.2	1.9	0.20	0.066	0.13
30	60	50	4.28	19.6	17.5	2.1	0.16	0.067	0.09
Dec. 1	71	63	4.25	19.3	16.0	3.3	0.18	0.070	0.11
2	67	61	4.33	21.4	19.7	1.7	0.20	0.077	0.12
3	70	61	4.97	13.3	11.6	1.7	0.21	0.076	0.13
4	71	60	5.13	16.4	14.6	1.8	0.22	0.075	0.14
5	69	58	5.35	13.9	11.6	2.3	0.22	0.078	0.14
6	71	61	5.33	19.6	17.5	2.1	0.23	0.080	0.15
7	69	50	5.42	18.4	15.2	3.2	0.27	0.083	0.19
8	69	52	5.74	26	22.4	4.0	0.25	0.087	0.16
9	76	62	5.63	16.3	14.4	1.9	0.24	0.083	0.16
10	63	61	5.13	24	19.9	4.0	0.23	0.081	0.15
11	61	55	5.26	26	20.2	6.0	0.26	0.084	0.18
12	53	47	5.08	29	22.3	7.0	0.24	0.089	0.15
13	45	43	4.83	27	22.8	4.0	0.22	0.077	0.14
Mean	64	56	4.61	18.8	15.9	2.9	0.20	0.064	0.13
Stan. Dev.	6	5	0.54	4.1	3.4	1.6	0.04	0.016	0.03

TABLE A-39. SUMMARY DATA SHEET, MORIARTY, #3 CHLORINATED LAGOON EFFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C	Daily Total Flow mgd†
Nov. 14	74	61	273	33	8	< 1	8.8	8.8	9.1	9.1	9.5	0.050
15	67	53	280	21	19	< 1	9.4	8.9	8.7	8.5	10.0	0.050
16	60	47	267	20	11	8	8.9	8.7	9.0	8.7	9.0	0.050
17	68	55	290	18	11	82	9.3	8.8	9.3	8.6	11.0	0.050
18	80	66	281	28	11	220	9.2	8.8	9.7	8.6	9.0	0.050
19	85	74	276	24	7	500	9.7	8.9	10.5	8.7	10.0	0.050
20	86	70	273	15	4	335	9.3	8.7	12.3	8.7	8.0	0.050
21	134	116	274	20	13	10	8.7	8.7	9.0	8.6	9.0	0.050
22	79	69	270	22	11	394	10.7	8.8	11.0	8.7	9.0	0.050
23	90	76	252	19	9	420	11.1	8.6	12.4	9.1	7.0	0.050
24	84	71	269	24	13	< 1	10.4	8.7	9.7	8.9	7.0	0.050
25	103	81	269	27	14	395	10.0	8.7	13.1	9.0	8.0	0.050
26	118	86	272	31	8	90	10.5	8.8	11.1	8.9	10.0	0.050
27	95	87	264	21	8	290	10.1	8.8	13.3	9.0	8.5	0.050
28	89	78	265	43/27	13/14	90	10.4	8.9	12.4	9.1	7.0	0.050
29	87	78	274	30	16	< 1	10.6	8.9	11.1	9.1	6.0	0.050
30	93	76	268	22	10	320	11.2	8.9	13.7	8.9	7.5	0.050
Dec. 1	99	92	261	10	-	645	10.6	8.7	14.0	8.9	4.0	0.050
2	89	87	281	35	9	< 1	9.3	8.7	13.1	8.9	5.0	0.050
3	91	78	269	29	14	995	40.2	8.5	12.0	8.9	7.0	0.050
4	116	86	267	24	12	1000	9.8	8.4	12.5	8.9	7.5	0.050
5	110	87	289	27/30	9/11	< 1	9.8	8.7	12.4	8.9	6.5	0.050
6	94	65	283	28	18	< 1	-	8.7	-	8.7	6.5	0.050
7	87	74	295	23	14	< 1	9.5	8.8	9.9	8.8	7.5	0.050
8	99	57	291	14	6	1200	9.2	8.7	13.5	8.9	7.0	0.050
9	105	33	293	19	7	1030	9.7	8.7	15.6	9.0	5.5	0.050
10	110	32	304	16	9	110	11.1	8.7	11.4	8.7	5.5	0.050
11	86	72	295	34	9	< 1	12.2	8.7	13.5	8.7	7.0	0.050
12	55	54	304	15	8	1110	11.3	8.7	13.4	8.8	5.5	0.050
13	100	64	310	-	-	1170	11.3	8.6	14.0	8.8	7.0	0.050
Mean	91	71	279	24/29	11/13	1.7040 L	10.1	8.7	11.7	8.8	7.6	0.050
Stan. Dev.	17	17	14	7/2	4/2	1.2470 L	0.9	0.1	1.9	0.2	0.2	0

/ - BOD_5/BOD_5 with nitrification inhibitor.

†Flow obtained by counting doses.

L = Log_{10}

TABLE A-40. SUMMARY DATA SHEET, MORIARTY, #3 CHLORINATED LAGOON EFFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Nov. 14	36	21	3.94	18.8	13.3	5.5	0.09	0.042	0.05
15	35	21	4.43	16.3	11.6	4.7	0.13	0.056	0.07
16	36	24	4.16	14.3	12.1	2.2	0.17	0.060	0.11
17	35	26	4.22	13.8	12.1	1.7	0.13	0.050	0.08
18	33	25	4.30	12.6	10.5	2.1	0.13	0.045	0.09
19	29	23	4.11	13.6	11.8	1.8	0.17	0.059	0.11
20	29	25	4.37	14.2	12.1	2.1	0.17	0.059	0.11
21	30	25	4.42	15.9	14.5	1.4	0.17	0.058	0.11
22	34	30	4.19	13.4	12.3	1.1	0.18	0.059	0.12
23	31	26	4.29	14.6	14.3	0.3	0.19	0.063	0.13
24	32	29	4.46	15.1	14.4	0.7	0.20	0.066	0.13
25	43	30	4.07	15.0	14.0	1.0	0.18	0.065	0.11
26	42	40	4.33	15.6	14.5	1.1	0.18	0.069	0.11
27	45	40	4.28	14.1	12.9	1.2	0.20	0.073	0.13
28	39	30	4.20	15.2	14.8	0.4	0.21	0.074	0.14
29	39	23	4.09	13.8	12.6	1.2	0.20	0.070	0.13
30	42	36	4.25	16.1	15.4	0.7	0.17	0.071	0.10
Dec. 1	42	30	4.46	15.9	14.4	1.5	0.16	0.065	0.10
2	41	29	4.71	17.1	16.0	1.1	0.19	0.059	0.13
3	44	32	4.89	16.3	14.8	1.5	0.20	0.073	0.13
4	38	29	4.92	21.3	19.7	1.6	0.20	0.072	0.13
5	44	34	4.98	17.2	15.6	1.6	0.22	0.077	0.14
6	43	30	4.48	22.1	20.3	1.8	0.22	0.076	0.14
7	44	36	3.13	20.2	18.9	1.3	0.23	0.078	0.15
8	37	22	5.31	22.1	19.7	2.4	0.23	0.078	0.15
9	41	32	5.61	26	24.3	2.0	0.24	0.080	0.16
10	36	22	4.21	21.2	18.9	2.3	0.25	0.083	0.17
11	25	24	4.53	19.9	19.1	0.8	0.24	0.080	0.16
12	22	22	4.66	23	21.2	2.0	0.22	0.079	0.14
13	35	34	4.02	20.6	19.1	1.5	0.23	0.078	0.15
Mean	37	28	4.40	17.2	15.5	1.7	0.19	0.065	0.12
Stan. Dev.	6	5	0.45	3.5	3.5	1.1	0.04	0.012	0.03

TABLE A-41. SUMMARY DATA SHEET, MORIARTY, #4 FILTER EFFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
Nov. 14	15	11	223	14	-	1	8.3	8.3	N.S.	N.S.	N.S.
15	16	4	242	12	-	< 1	8.5	8.1	N.S.	N.S.	N.S.
16	3	2	236	13	-	200	8.9	8.3	N.S.	N.S.	N.S.
17	14	10	222	13	-	400	9.2	8.3	N.S.	N.S.	N.S.
18	24	12	215	14	-	80	9.2	8.0	N.S.	N.S.	N.S.
19	13	10	232	13	10	1000	8.9	8.5	N.S.	N.S.	N.S.
20	15	6	238	11	8	70	9.1	8.3	9.5	8.1	8.5
21	22	10	234	9	8	50	9.1	8.3	N.S.	N.S.	N.S.
22	14	4	232	7	7	500	9.4	8.3	N.S.	N.S.	N.S.
23	18	11	227	8	7	735	9.3	8.2	N.S.	N.S.	N.S.
24	10	6	229	7	9	160	9.9	8.2	N.S.	N.S.	N.S.
25	24	7	233	11	12	435	9.7	8.3	9.3	8.1	8.0
26	18	6	233	5	6	665	9.7	8.1	N.S.	N.S.	N.S.
27	10	8	218	8	9	25	9.3	8.1	8.7	8.3	10.0
28	4	3	210	7/9	8/5	260	9.5	8.1	N.S.	N.S.	N.S.
29	15	14	229	10	13	45	10.2	8.3	N.S.	N.S.	N.S.
30	8	7	232	14	11	70	9.9	8.5	N.S.	N.S.	N.S.
Dec. 1	12	10	211	10	12	325	10.1	8.1	N.S.	N.S.	N.S.
2	4	3	229	12	10	20	10.2	8.2	9.5	8.1	8.0
3	7	4	237	10	13	< 1	10.0	8.3	9.6	8.3	8.0
4	39	11	236	12	12	1070	10.0	8.1	9.3	8.3	8.5
5	14	9	237	12/8	-/6	260	9.9	8.3	9.8	8.1	8.0
6	13	2	238	9	9	< 1	-	8.3	N.S.	8.1	8.5
7	17	8	252	9	10	50	9.6	8.5	N.S.	N.S.	N.S.
8	17	1	262	5	5	300	9.3	8.3	N.S.	N.S.	N.S.
9	13	5	245	6	5	900	9.7	8.3	N.S.	N.S.	N.S.
10	22	15	254	8	5	180	10.3	8.3	9.5	8.0	9.0
11	11	7	255	6	8	70	10.7	8.3	9.7	8.3	8.5
12	10	8	264	6	10	120	10.2	8.2	9.7	8.1	7.0
13	17	0	260	-	-	200	10.2	8.2	9.4	7.9	8.0
Mean	15	7	236	10/9	9/6	1.9590 L	9.6	8.3	9.4	8.1	8.3
Stan. Dev.	7	4	14	3/1	2/1	0.9091 L	0.6	0.1	0.4	0.1	1.0

N.S. - No sample.

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-42. SUMMARY DATA SHEET, MORIARTY, #4 FILTER EFFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Nov. 14	14	9	2.50	2.9	0.28	2.6	3.6	0.18	3.4
15	16	9	2.75	3.2	0.32	2.9	2.2	0.36	1.8
16	23	14	2.80	3.4	0.35	3.1	2.0	0.62	1.4
17	19	15	2.26	2.9	0.46	2.4	3.6	1.3	2.3
18	23	11	1.94	2.9	0.61	2.3	5.0	2.0	3.0
19	15	11	2.05	3.4	0.48	2.9	3.9	0.79	3.1
20	16	11	2.82	2.6	0.58	2.0	10.6	2.4	8.2
21	15	9	2.48	3.1	0.51	2.6	7.6	2.5	5.1
22	18	11	2.02	2.7	0.48	2.2	4.9	1.6	3.3
23	19	6	2.62	2.1	0.70	1.4	7.3	1.8	5.5
24	16	9	2.56	2.8	1.10	1.7	6.2	2.0	4.2
25	27	15	1.94	2.2	1.08	1.1	2.6	1.2	1.4
26	23	16	2.09	3.1	0.91	2.2	2.9	0.80	2.1
27	24	15	2.54	2.5	1.31	1.2	7.4	2.8	4.6
28	20	16	2.54	2.1	1.25	0.9	5.6	2.0	3.6
29	20	11	2.20	2.3	1.71	0.6	2.4	0.90	1.5
30	17	9	2.26	2.9	1.31	1.6	3.1	2.0	1.1
Dec. 1	20	11	2.49	2.1	1.00	1.1	7.7	3.5	4.2
2	25	19	2.63	3.0	1.56	1.4	5.9	2.1	3.8
3	31	27	2.74	2.1	0.11	2.0	2.1	0.90	1.2
4	19	15	2.82	2.4	0.11	2.3	3.1	0.75	2.3
5	24	15	3.11	3.2	0.16	3.0	8.0	2.4	5.6
6	24	15	3.24	1.9	0.34	1.6	7.0	2.4	4.6
7	24	12	3.13	2.1	1.33	0.8	3.3	1.2	2.1
8	14	7	3.16	1.6	0.25	1.3	4.0	1.4	2.6
9	23	13	3.25	1.4	0.15	1.2	8.2	3.7	4.5
10	17	15	3.24	2.8	2.75	0.1	7.8	2.0	5.8
11	12	8	3.29	4.9	4.69	0.2	2.5	0.75	1.8
12	17	16	3.14	4.6	4.38	0.2	1.3	0.36	0.9
13	19	15	2.81	4.3	3.94	0.4	2.9	0.82	2.1
Mean	20	13	2.65	2.8	1.14	1.6	4.8	1.58	3.2
Stan. Dev.	4	4	0.42	0.8	1.24	0.9	2.4	0.91	1.7

TABLE A-43. SUMMARY DATA SHEET, MORIARTY, #1 LAGOON INFLUENT (FIELD)

1978 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C	Daily Total Flow mgd
Feb. 14	134	114	486	121	61	4.95×10^6	1.5	8.2	1.6	8.2	10.0	0.093
15	164	144	492	171	84	3.96×10^6	3.9	8.3	3.0	8.1	11.0	0.097
16	179	139	439	135	67	3.5×10^6	1.6	8.1	1.6	8.1	12.0	0.100
17	178	136	511	212	93	3.65×10^6	1.0	8.1	2.0	8.1	13.0	0.087
18	202	176	501	198	92	3.4×10^6	3.4	8.2	0.5	8.0	8.0	0.097
19	110	94	431	197	100	3.15×10^6	3.9	8.2	3.2	8.1	12.0	0.096
20	84	73	433	157	108^a	3.95×10^6	2.6	8.3	1.9	8.1	15.0	0.101
21	162	128	456	184	76	3.2×10^6	2.4	8.2	0.5	8.0	17.0	0.100
22	202	118	464	135	90	4.05×10^6	0.8	8.3	1.5	8.1	16.0	0.100
23	112	95	442	155	90	4.4×10^6	1.7	8.3	0.1	8.1	16.0	0.090
24	186	74	472	254	85	3.8×10^6	1.9	8.2	1.3	8.1	14.0	0.102
25	346	316	452	284	63	3.15×10^6	3.3	8.3	0.2	7.9	16.0	0.101
26	154	166	470	164	72	2.7×10^6	0.6	8.1	1.3	8.1	17.0	0.089
27	184	148	437	198	71	N.S.	0.5	8.1	1.8	8.1	14.0	0.111
28	194	164	429	129	68	3.3×10^6	0.6	8.3	1.5	8.0	17.0	0.091
Mar. 1	140	130	464	151	74	2.9×10^6	0.7	8.2	2.9	8.1	14.0	0.104
2	142	118	471	170/129	57/64	4.05×10^6	.6	8.3	0.8	8.1	17.0	0.095
3	100	92	464	149^a	77	2.8×10^6	0.8	8.1	0.7	8.1	15.0	0.108
4	162	130	424	201	59	2.05×10^6	2.6	8.3	0.4	8.1	16.0	0.084
5	118	106	430	129	88	2.2×10^5	0.6	8.1	1.1	8.1	16.0	0.105
6	162	140	449	290^a	78	2.7×10^6	0.8	8.1	0.4	8.2	16.0	0.112
7	120	60	444	135	70^a	2.45×10^6	0.6	8.3	0.5	8.1	16.0	0.094
8	88	48	449	173	72^a	1.85×10^6	1.0	8.3	1.8	8.3	16.0	0.098
9	96	52	440	208	150^a	2.8×10^6	0.4	8.1	1.9	8.3	15.0	0.107
10	258	218	440	161	83^a	2.45×10^6	0.8	8.3	1.7	8.3	12.0	0.114
11	59	30	408	131	115	4.2×10^6	1.6	8.3	0.5	8.2	14.0	0.088
12	134	112	424	261^a	86	5.2×10^6	2.0	8.3	2.6	8.3	12.0	0.105
13	94	80	455	106	73^a	3.35×10^6	3.1	8.4	1.5	8.4	12.0	0.120
14	140	124	452	136	57	10.2×10^6	2.0	8.3	1.0	8.5	14.0	0.117
15	248	190	420	200	91^a	4.2×10^6	4.9	8.5	1.8	8.5	12.0	0.104
Mean	155	124	451	177/129	82/64	6.3080 L	1.7	8.2	1.4	8.2	14.2	0.100
Stan. Dev.	59	56	24	48/0	19/0	1.2000 L	1.2	0.1	0.8	0.1	2.3	0.009

^{a}Outside 40-70% limit.

/ - BOD_5/BOD_5 with nitrification inhibitor.

N.S. - No sample.

L = Log_{10}

TABLE A-44. SUMMARY DATA SHEET, MORIARTY, #1 LAGOON INFLUENT (UWRL)

1978 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Feb. 14	305	213	13.15	92	35	57	0.01	0.005	0.00
15	310	186	15.24	92	40	52	0.04	0.032	0.01
16	295	196	13.45	88	36	52	0.06	0.020	0.04
17	259	195	14.53	90	39	51	0.01	0.005	0.00
18	313	207	13.61	89	38	51	0.01	0.005	0.00
19	293	219	14.68	91	34	57	0.01	0.006	0.00
20	265	195	12.78	89	33	56	0.04	0.014	0.03
21	267	230	12.28	89	36	53	0.04	0.006	0.03
22	310	236	11.67	87	39	48	0.05	0.005	0.04
23	305	244	12.28	91	40	51	0.06	0.004	0.06
24	273	236	11.97	89	36	53	0.02	0.004	0.02
25	299	228	13.79	88	34	54	0.02	0.004	0.02
26	275	230	12.74	88	37	51	0.03	0.005	0.02
27	263	226	13.51	89	35	54	0.04	0.005	0.04
28	292	236	12.28	87	35	52	0.06	0.006	0.05
Mar. 1	240	221	12.19	92	38	54	0.04	0.005	0.04
2	282	219	11.54	88	33	55	0.06	0.006	0.05
3	270	229	10.65	90	30	60	0.07	0.006	0.06
4	254	195	11.54	89	33	56	0.07	0.005	0.06
5	268	198	10.77	86	26	60	0.07	0.005	0.06
6	262	189	11.73	91	34	57	0.13	0.094	0.04
7	264	193	8.49	91	29	62	0.01	0.003	0.01
8	294	222	9.60	75	33	42	0.02	0.004	0.02
9	268	187	8.68	85	29	56	0.03	0.004	0.03
10	272	181	11.23	91	35	56	0.09	0.041	0.05
11	252	192	7.91	88	31	57	0.57	0.45	0.12
12	226	181	8.65	90	30	60	0.27	0.20	0.07
13	289	216	11.78	83	33	50	0.02	0.006	0.01
14	267	172	12.06	91	33	58	0.03	0.006	0.02
15	277	202	14.31	88	27	61	0.04	0.006	0.03
Mean	276	209	11.97	89	34	54	0.07	0.032	0.04
Stan. Dev.	22	20	1.89	3	4	4	0.11	0.088	0.02

TABLE A-45. SUMMARY DATA SHEET, MORIARTY, #2 LAGOON EFFLUENT (FIELD)

1978 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
Feb. 14	83	73	382	21[a]	9	180	13.1	8.7	14.6	8.9	2.5
15	77	76	388	34	13	45	14.7	8.6	15.1	8.8	4.0
16	82	61	336	18[a]	10	130	13.4	8.7	16.2	8.1	3.5
17	73	58	370	19[a]	9	80	12.5	8.7	17.0	9.0	5.0
18	69	50	383	14[a]	11	42	15.9	8.8	16.5	8.9	3.0
19	61	50	358	21	13	96	15.3	8.7	18.8	8.9	4.5
20	66	53	349	22[a]	11	100	13.9	8.5	16.2	8.7	7.0
21	70	47	345	21	11	12	14.2	8.7	13.6	8.9	9.0
22	55	15	348	16[a]	13	78	14.3	8.7	12.8	8.9	10.0
23	40	25	341	13[a]	13	82	14.9	8.8	12.5	8.8	11.0
24	67	38	331	41	20	82	11.5	8.6	13.0	8.8	8.0
25	69	62	357	19	13	78	11.3	8.7	13.1	8.7	9.0
26	57	52	342	28	16	74	10.8	8.7	12.9	8.7	11.0
27	72	63	338	24	20[a]	N.S.	10.7	8.7	15.6	8.7	7.0
28	77	68	340	25	13	70	10.2	8.7	12.7	8.7	10.0
Mar. 1	77	71	329	24	17[a]	180	9.0	8.6	11.0	8.9	9.0
2	77	70	348	43/32[a]	15/15	166	9.3	8.6	11.0	9.0	9.0
3	76	62	348	31	22[a]	100	11.4	8.7	12.0	8.9	10.0
4	90	76	334	42	13	48	11.8	8.8	11.1	9.0	11.0
5	90	78	332	25	14	86	11.1	8.8	10.8	9.0	10.0
6	84	77	326	> 76[a]	24	56	10.2	8.9	12.1	9.1	11.0
7	80	58	337	23	11	42	10.9	8.9	14.5	9.0	11.0
8	15	10	331	> 82[a]	26	20	11.0	8.9	13.0	9.1	10.0
9	73	59	349	30	> 40[a]	42	11.2	8.7	12.0	9.1	12.0
10	111	99	324	> 77[a]	32[a]	62	10.3	8.9	11.8	9.1	7.0
11	62	50	323	36	17[a]	64	11.1	8.9	14.2	9.2	10.0
12	80	55	333	42	16	84	9.0	8.9	12.4	9.0	8.0
13	72	65	320	23	36[a]	112	8.8	8.5	10.9	9.1	8.0
14	60	55	341	33	13[a]	106	8.6	8.8	11.0	9.1	8.0
15	76	65	342	26	35[a]	82	10.5	8.9	11.4	9.1	6.0
Mean	71	58	344	32/32	18/15	1.7940 L.	11.7	8.7	13.3	8.9	8.1
Stan. Dev.	17	19	17	18/0	8/0	0.4219 L.	2.1	0.1	2.1	0.2	2.7

[a] Outside 40-70% limit.

/ - BOD_5/BOD_5 with nitrification inhibitor.

N.S. - No sample.

L = Log_{10}

TABLE A-46. SUMMARY DATA SHEET, MORIARTY, #2 LAGOON EFFLUENT (UWRL)

1978 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Feb. 14	39	29	5.99	29	27	2	0.25	0.135	0.11
15	41	33	5.80	31	27	4	0.23	0.135	0.10
16	39	26	5.74	30	26	4	0.31	0.140	0.17
17	40	25	5.77	28	26	2	0.28	0.140	0.14
18	45	37	5.22	34	26	8	0.27	0.140	0.13
19	43	36	5.39	33	26	7	0.27	0.135	0.14
20	41	33	5.53	29	26	3	0.28	0.140	0.14
21	37	30	5.21	35	30	5	0.24	0.135	0.10
22	41	35	4.79	36	28	8	0.27	0.125	0.14
23	45	30	4.45	36	29	7	0.29	0.120	0.17
24	42	33	5.21	35	28	7	0.23	0.125	0.10
25	45	40	5.21	36	26	10	0.24	0.130	0.11
26	41	30	5.37	35	35	0	0.25	0.140	0.11
27	48	37	5.21	35	29	6	0.26	0.140	0.12
28	43	30	5.97	36	28	8	0.26	0.150	0.11
Mar. 1	34	29	4.69	32	21	11	0.30	0.155	0.14
2	49	42	4.92	32	25	7	0.28	0.170	0.11
3	49	45	4.97	30	22	8	0.27	0.165	0.10
4	48	45	4.92	32	21	11	0.27	0.160	0.11
5	49	43	4.85	32	24	8	0.28	0.155	0.12
6	50	43	4.92	32	24	8	0.28	0.160	0.12
7	40	33	3.80	32	25	7	0.26	0.160	0.10
8	41	32	3.66	32	25	7	0.28	0.175	0.10
9	50	39	3.49	31	22	9	0.30	0.190	0.11
10	55	45	3.63	32	23	9	0.31	0.200	0.11
11	53	37	3.62	31	24	7	0.32	0.205	0.12
12	54	32	3.65	32	21	11	0.33	0.220	0.11
13	39	37	4.66	31	22	9	0.31	0.220	0.09
14	48	39	4.88	32	25	7	0.37	0.235	0.14
15	58	38	4.97	32	24	8	0.36	0.225	0.14
Mean	45	35	4.88	32	25	7	0.28	0.161	0.12
Stan. Dev.	6	6	0.74	2	3	2	0.03	0.033	0.02

TABLE A-47. SUMMARY DATA SHEET, MORIARTY, #3 CHLORINATED LAGOON EFFLUENT (FIELD)

1978 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C	Daily Total Flow mgd[†]
Feb. 14	75	68	375	21	12	< 1	11.8	8.6	12.8	8.9	3.0	0.050
15						< 1	N.S.	N.S.	16.3	8.9	4.0	0.050
16	78	60	346	20[a]	12	2	12.3	8.7	15.2	8.8	3.0	0.050
17						< 1	N.S.	N.S.	14.2	8.8	6.0	0.050
18	68	50	354	20[a]	14	5	13.0	8.8	18.0	8.9	3.0	0.050
19	62	2	357	25	16	< 1	14.0	8.7	17.1	8.9	4.0	0.050
20	61	52	367	24	18	< 1	12.9	8.7	15.8	8.8	5.0	0.050
21	72	55	367	25[a]	> 25[a]	< 1	13.1	8.7	14.3	8.9	7.0	0.050
22	63	46	357	18	16	< 1	13.4	8.8	14.0	8.9	8.0	0.050
23	41	32	333	29	18	1	13.7	8.9	13.0	8.9	10.0	0.050
24	74	43	321	39	20[a]	< 1	11.4	8.7	10.6	8.7	10.0	0.050
25	63	58	362	34	20	< 1	11.4	8.7	11.1	8.7	10.0	0.050
26	58	45	358	35	19	< 1	11.2	8.7	12.2	8.8	11.0	0.050
27	64	53	360	29	18	< 1	11.0	8.7	13.5	8.7	8.0	0.050
28	84	70	373	23[a]	20	< 1	10.3	8.7	11.1	8.7	10.0	0.050
Mar. 1	90	79	357	44	20	< 1	10.2	8.8	11.7	8.9	10.0	0.050
2	77	67	362	40/29	23/21	< 1	9.9	8.7	13.2	9.0	10.0	0.050
3	76	67	339	> 80[a]	15	< 1	10.6	8.7	12.2	9.0	10.0	0.050
4	81	69	342	> 80[a]	26	< 1	10.6	8.7	11.0	9.0	10.0	0.050
5	81	72	318	31	32[a]	< 1	11.0	8.6	10.0	9.0	10.0	0.050
6	83	74	331	59[a]	24	< 1	9.7	8.7	12.4	9.1	12.0	0.050
7	75	56	333	37	22	< 1	10.5	8.9	12.0	9.1	11.0	0.050
8	28	19	344	43	19	< 1	10.6	8.9	13.3	9.1	11.0	0.050
9	70	48	344	33	> 40[a]	3	10.5	8.9	11.0	9.1	12.0	0.050
10	113	99	342	> 69[a]	34[a]	< 1	9.7	9.0	11.8	9.1	8.0	0.050
11	72	69	323	38	> 41[a]	< 1	9.3	8.9	11.4	9.2	10.0	0.050
12	90	72	344	38	> 82[a]	< 1	9.1	8.9	12.0	9.1	8.0	0.050
13	69	7	349	69[a]	> 75[a]	< 1	9.3	8.9	11.0	9.1	9.0	0.050
14	64	53	362	33	23	1	9.3	8.9	8.9	9.0	8.0	0.050
15	97	80	330	31	29	60	9.8	8.9	12.2	9.1	7.0	0.050
Mean	72	56	348	38/29	26/21	0.1085 L	11.1	8.8	12.8	8.9	8.3	0.050
Stan. Dev.	16	22	16	18/0	16/0	0.3531 L	1.5	0.1	2.1	0.1	0.3	0

[a] Outside the 40-70% limit.

/ - BOD_5/BOD_5 with nitrification inhibitor.

N.S. - No sample.

L = Log_{10}

[†] Flow obtained by counting doses.

TABLE A-48. SUMMARY DATA SHEET, MORIARTY, #3 CHLORINATED LAGOON EFFLUENT (UWRL)

1978 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Feb. 14	29	21	5.80	28	27	1	0.26	0.140	0.12
15	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
16	23	16	5.65	29	24	5	0.33	0.150	0.18
17	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
18	39	25	5.16	29	26	3	0.30	0.150	0.15
19	35	25	5.26	29	26	3	0.31	0.150	0.16
20	29	19	5.53	26	26	0	0.29	0.145	0.14
21	24	18	5.37	31	30	1	0.26	0.145	0.12
22	26	18	4.89	29	27	2	0.29	0.140	0.15
23	23	15	4.42	32	31	1	0.32	0.135	0.18
24	22	17	6.11	29	23	6	0.23	0.130	0.10
25	26	18	5.39	29	26	3	0.25	0.140	0.11
26	24	18	5.36	31	30	1	0.26	0.145	0.12
27	26	18	5.45	29	28	1	0.27	0.145	0.12
28	25	18	5.51	35	33	2	0.27	0.150	0.12
Mar. 1	18	16	5.25	29	23	6	0.28	0.150	0.13
2	27	24	5.12	28	24	4	0.28	0.155	0.12
3	26	20	5.00	28	20	8	0.28	0.165	0.12
4	23	18	4.86	29	23	6	0.28	0.160	0.12
5	20	11	4.72	30	24	6	0.29	0.160	0.13
6	30	18	4.99	29	25	4	0.33	0.165	0.16
7	32	28	3.77	29	20	9	0.28	0.165	0.12
8	34	27	3.55	30	21	9	0.30	0.180	0.12
9	39	29	3.46	30	19	11	0.31	0.190	0.12
10	36	29	4.08	31	21	10	0.32	0.200	0.12
11	39	24	3.49	30	25	5	0.31	0.195	0.12
12	37	24	3.80	29	24	5	0.32	0.205	0.12
13	28	15	4.78	29	23	6	0.30	0.215	0.08
14	38	29	4.88	30	23	7	0.33	0.215	0.12
15	31	17	5.92	29	24	5	0.35	0.215	0.14
Mean	29	21	4.91	29	25	5	0.29	0.164	0.13
Stan. Dev.	6	5	0.75	2	3	3	0.03	0.026	0.02

N.S. - No sample.

TABLE A-49. SUMMARY DATA SHEET, MORIARTY, #4 FILTER EFFLUENT (FIELD)

1978 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ
Feb. 14	9	8	298	6[a]	8	< 1	10.6	8.3		No Flow	
15	8	6	307	9	8	< 1	11.1	8.1	10.3	7.9	4.0
16	15	13	304	9	10[a]	2	10.0	8.3	9.6	8.1	3.0
17	14	13	317	11	9	5	10.4	8.2	8.8	7.9	8.5
18	4	3	310	9[a]	10	3	9.7	8.1	9.4	7.9	2.5
19	6	4	326	14	10	3	9.8	8.2	10.3	8.2	4.0
20	7	5	351	8	9	< 1	9.6	8.3	9.6	7.9	6.0
21	18	3	296	11	9	1	9.5	8.3	9.3	7.9	8.0
22	15	9	285	11	10	< 1	9.1	8.2		No Flow	
23	4	3	272	9	10	5	9.9	8.2		No Flow	
24	9	6	315	13	12	14	9.5	8.3		No Flow	
25	8	3	317	19[a]	11	< 1	9.4	8.2		No Flow	
26	2	1	297	15	12	2	9.3	8.3		No Flow	
27	3	1	280	17	12	< 1	9.4	8.2	9.0	7.8	9.0
28	8	7	313	13	>20[a]	21	9.4	8.3	9.4	7.8	9.0
Mar. 1	4	2	294	> 22[a]	18[a]	3	8.9	8.3		No Flow	
2	3	1	310	> 22/9[a]	16/11	16	8.8	8.1		No Flow	
3	6	5	300	> 21[a]	15[a]	< 1	8.9	8.3	9.4	8.1	10.0
4	11	8	280	> 21[a]	16[a]	2	9.1	8.1	8.3	7.8	11.0
5	8	6	308	20[a]	17[a]	2	8.8	8.3		No Flow	
6	9	6	278	> 40[a]	30[a]	< 1	8.8	8.3	8.5	7.9	12.0
7	2	1	284	> 36[a]	13[a]	< 1	8.9	8.3	9.1	8.1	10.0
8	3	1	305	> 42[a]	16[a]	3	8.9	8.4	8.6	7.9	10.0
9	8	2	286	> 40[a]	6[a]	4	8.7	8.4	8.9	7.7	12.0
10	26	8	270	> 39[a]	34[a]	< 1	8.6	8.2	8.8	7.9	8.0
11	5	4	253	> 40[a]	>42[a]	1	8.5	8.4	8.2	8.1	10.0
12	11	5	321	30	8[a]	5	8.8	8.4		No Flow	
13	9	6	288	> 39[a]	37	8	8.5	8.4		No Flow	
14	7	6	268	20	51[a]	1	8.6	8.4		No Flow	
15	9	5	267	27	21	4	9.2	8.3		No Flow	
Mean	8	5	297	21/9	17/11	0.3663	9.3	8.3	9.1	7.9	8.1
Stan. Dev.	5	3	21	12/0	11/0	0.4054	0.6	0.1	0.6	0.1	3.1

[a] Outside the 40-70% limit.

/ - BOD_5/BOD_5 with nitrification inhibitor.

TABLE A-50. SUMMARY DATA SHEET, MORIARTY, #4 FILTER EFFLUENT (UWRL)

1978 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Feb. 14	17	12	4.62	24	20	4	15.3	4.4	10.9
15	17	15	4.20	22	21	1	2.50	0.67	1.83
16	15	8	4.33	23	23	0	4.10	1.20	2.90
17	8	4	4.54	22	22	1	1.80	0.60	1.20
18	17	15	4.29	23	19	4	8.45	1.98	6.47
19	18	15	4.54	22	19	3	4.50	1.08	3.42
20	17	8	4.39	26	24	2	1.35	0.35	1.00
21	18	9	4.29	24	23	1	6.10	1.10	5.00
22	19	9	4.26	26	25	1	6.35	0.465	5.88
23	16	8	3.41	23	20	3	8.45	1.50	6.95
24	16	8	4.39	22	22	0	1.85	0.255	1.60
25	17	8	4.06	26	24	2	6.55	2.22	4.33
26	16	8	4.06	23	21	2	13.0	2.15	10.8
27	17	9	4.00	24	23	1	14.0	4.2	9.8
28	15	8	3.99	26	23	3	7.35	2.42	4.93
Mar. 1	16	10	3.59	25	24	1	17.8	4.0	13.8
2	18	13	3.77	24	21	3	19.0	3.4	15.6
3	20	12	3.62	22	22	0	6.65	1.35	5.30
4	18	12	3.77	23	22	1	6.25	2.02	4.23
5	10	8	3.59	25	23	2	5.65	1.70	3.95
6	24	16	3.77	25	17	8	16.8	1.92	14.9
7	17	14	2.89	23	21	2	15.5	2.80	12.7
8	14	8	3.18	24	24	0	7.25	1.90	5.35
9	16	10	2.88	28	26	2	16.0	3.2	12.8
10	24	16	3.32	24	17	7	26.2	4.2	22.0
11	20	14	3.18	24	18	6	14.5	2.35	12.2
12	20	10	3.03	28	26	2	4.30	0.92	3.38
13	15	9	3.38	25	21	4	21.0	3.6	17.4
14	13	8	3.55	25	9.4	16	27.0	2.25	24.8
15	18	13	3.70	25	16	9	26.5	3.7	22.8
Mean	17	11	3.82	24	21	4	11.07	2.130	8.94
Stan. Dev.	3	3	0.51	2	3	3	7.67	1.245	6.72

Table A-51. SUMMARY DATA SHEET, AILEY, #1 LAGOON INFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
Mar. 19	471	313	47	96	22	260,000	6.9	7.0	6.9	6.9	17.5
20	81	58	49	69	20	410,000	7.6	7.0	7.4	6.9	16.0
21	67	48	49	56	15	530,000	6.3	7.0	6.7	7.0	13.5
22	58	50	51	72	23	260,000	8.4	7.2	7.4	7.2	14.0
23	107	70	47	78	14	1,350,000	8.5	7.0	7.6	7.2	13.0
24	82	61	48	71	20	775,000	8.6	7.0	7.5	7.3	14.0
25	83	52	47	22[a]	7[a]	425,000	8.2	7.0	7.6	7.2	15.0
26	68	49	46	52[a]	21	700,000	8.1	7.0	7.2	7.2	15.0
27	61	57	49	30[a]	10	325,000	7.6	7.0	6.9	7.1	15.0
28	71	67	51	44[a]	9[a]	2,200,000	7.7	7.3	6.2	7.4	17.5
29	112	110	55	47[a]	7[a]	1,350,000	6.5	6.9	6.5	7.3	18.0
30	106	76	49	49[a]	12	1,550,000	7.0	6.9	6.4	7.3	17.5
31	19	16	55	48	11	205,000	6.2	7.1	6.6	7.4	18.0
Apr. 1	82	1	53	37	14	615,000	6.1	7.1	6.2	7.3	16.0
2	81	35	50	29	11	615,000	6.4	6.8	6.4	7.2	18.5
3	45	40	49	44/34	13/13	475,000	5.2	7.0	6.1	7.2	20.5
4	N.S.	N.S.	N.S.	N.S.	N.S.	1,500,000	N.S.	N.S.	4.7	7.3	20.0
5	105	94	67	71	11	400,000	3.8	7.2	6.5	7.4	17.0
6	210	121	64	58	12	390,000	6.8	7.4	6.6	7.5	16.0
7	86	67	63	49	14	450,000	7.0	7.4	6.7	7.4	16.0
8	51	31	66	49	20[a]	1,100,000	6.2	7.3	5.8	7.4	17.0
9	68	55	73	66/73	12/12	105,000	5.4	7.2	5.7	7.4	16.0
10	44	8	74	50	12	700,000	6.1	7.4	5.8	7.2	17.5
11	129	95	66	53	15[a]	450,000	5.5	7.0	4.9	7.4	18.0
12	127	93	85	137[a]	15	850,000	5.4	7.3	6.3	7.4	18.0
13	322	270	76	>50	15	500,000	7.5	7.4	5.6	7.6	19.0
14	175	113	86	84	>17	210,000	5.7	7.2	5.4	7.4	18.0
15	122	117	92	87	20	850,000	5.5	7.2	5.2	7.6	18.0
16	172	138	94	175	17	1,400,000	5.2	7.3	5.1	7.4	18.0
17	168	127	98	59	22	1,000,000	4.7	7.2	4.2	7.4	20.0
Mean	116	84	62	63/53	15/13	5.7670 L	6.6	7.1	6.3	7.3	16.9
Stan. Dev.	91	68	16	31/28	5/1	0.3058 L	1.2	0.2	0.9	0.2	1.9

[a] Outside 40-70% depletion range.

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-52. SUMMARY DATA SHEET, AILEY, #1 LAGOON INFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Mar. 19	46	20	2.62	7.6	3.65	4.0	2.68	0.328	2.37
20	61	17	3.52	8.0	3.77	4.2	2.60	0.325	2.29
21	79	9	2.29	9.2	5.66	3.5	2.44	0.278	2.18
22	69	31	3.03	8.7	4.33	4.4	2.29	0.271	2.03
23	108	21	2.33	10.6	2.82	7.8	2.77	0.032	2.74
24	74	25	2.74	8.7	3.93	4.8	2.93	0.083	2.85
25	60	25	2.92	7.4	3.12	4.3	2.73	0.245	2.50
26	61	26	2.37	6.8	2.55	4.2	2.81	0.210	2.61
27	78	25	2.57	9.1	4.15	4.9	2.66	0.208	2.46
28	66	22	2.57	11.2	5.21	6.0	1.04	0.257	0.80
29	95	26	3.38	11.0	4.10	6.9	2.60	0.620	2.01
30	90	22	2.65	10.7	5.11	5.6	1.28	0.638	0.67
31	40	23	2.03	7.3	3.54	3.8	1.08	0.704	0.41
Apr. 1	126	26	2.17	10.1	4.74	5.4	1.14	0.604	0.57
2	99	22	2.12	10.0	3.29	6.7	2.31	0.606	1.73
3	99	21	2.55	9.7	4.82	4.9	2.00	0.584	1.44
4	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
5	130	26	3.32	12.6	5.19	7.4	1.77	0.509	1.29
6	154	25	2.81	14.3	4.77	9.5	2.54	0.599	1.97
7	116	26	2.92	12.2	6.11	6.1	2.48	0.639	1.87
8	81	26	2.47	10.6	5.28	5.3	2.65	0.601	2.08
9	98	28	3.77	11.4	7.10	4.3	2.16	0.542	1.65
10	60	34	3.26	10.4	7.35	3.0	1.06	0.381	0.70
11	109	27	2.85	15.4	7.35	8.0	2.36	0.542	1.85
12	168	33	5.15	16.6	6.44	10.2	1.90	0.413	1.51
13	371	28	4.71	25.0	5.91	19.1	2.67	0.668	2.04
14	216	34	4.28	19.5	7.89	11.6	1.73	0.155	1.58
15	149	38	4.36	17.8	7.81	10.0	2.00	0.217	1.79
16	156	38	4.34	18.7	8.16	10.5	2.06	0.207	1.86
17	162	40	5.18	19.7	8.51	11.2	1.82	0.189	1.64
Mean	111	26	3.15	12.1	5.26	6.8	2.16	0.402	1.78
Stan. Dev.	65	7	0.91	4.5	1.72	3.4	0.58	0.202	0.66

TABLE A-53. SUMMARY DATA SHEET, AILEY, #2 LAGOON EFFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
Mar. 19	240	22	46	18	8	10	7.9	8.4	7.1	8.5	20.0
20	22	17	47	17	8	18	8.1	8.0	6.6	8.0	19.5
21	29	25	50	16	7	25	7.7	7.9	6.1	7.7	19.0
22	13	9	49	14	7	67	8.3	7.5	7.1	7.6	17.5
23	24	8	48	11	5	82	9.1	7.3	8.2	7.6	16.5
24	18	1	49	16	6	30	9.4	7.6	8.9	8.0	16.0
25	46	19	47	7[a]	4	32	9.7	8.2	9.8	8.4	17.0
26	34	21	46	15	9	50	9.7	8.7	10.4	8.8	17.0
27	35	20	49	10[a]	5	55	10.1	9.3	11.0	9.2	17.0
28	34	31	51	10[a]	5	65	9.7	9.5	11.2	9.8	19.0
29	64	36	55	13	7	1	9.5	9.2	12.0	9.8	19.5
30	92	19	49	14	7	1	10.0	9.7	12.4	10.1	20.5
31	11	3	55	12	7	2	8.9	9.7	9.5	9.8	21.5
Apr. 1	8	1	53	8	9	56	8.1	9.3	7.3	9.5	21.0
2	54	12	50	8	7	57	8.2	9.3	7.8	9.4	21.5
3	27	22	49	12/10	11/11	38	7.9	8.9	8.1	9.4	22.0
4	32	25	45	10	6	36	7.6	9.3	7.8	9.5	23.0
5	36	25	48	9	6	5	6.8	9.0	7.2	9.2	22.0
6	30	24	49	7	5	7	8.9	9.0	9.0	9.2	19.0
7	19	18	46	11	6[a]	< 1	9.4	9.4	10.3	9.7	18.5
8	23	4	47	15	7	1	8.4	9.4	8.9	9.5	19.0
9	20	17	46	15/14	11/8	< 1	7.2	9.1	6.9	9.2	19.0
10	28	16	46	6	5	2	7.7	8.6	7.0	8.4	20.0
11	28	11	48	6	10	2	7.0	7.6	6.6	8.2	20.0
12	N.S.	N.S.	N.S.	N.S.	N.S.	2	N.S.	N.S.	7.1	8.0	21.0
13	57	38	48	9	11	1	7.3	7.6	7.3	7.9	22.0
14	19	18	48	8	>15[a]	5	7.3	7.4	6.8	7.8	21.0
15	18	14	49	4[a]	11[a]	6	7.4	7.3	7.0	7.7	22.0
16	37	22	49	5[a]	7	2	7.3	7.4	7.2	7.8	22.0
17	30	27	49	4[a]	7	3	7.7	7.5	8.2	8.3	23.0
Mean	31	18	49	11/12	8/9	0.9090 L	8.4	8.5	8.4	8.7	19.9
Stan. Dev.	18	9	2	4/3	3/2	0.7052 L	1.0	0.9	1.7	0.8	2.0

[a] Outside 40-70% range.

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-54. SUMMARY DATA SHEET, AILEY, #2 LAGOON EFFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Mar. 19	64	31	2.28	3.8	1.11	2.7	0.63	0.065	0.57
20	64	30	2.22	3.5	2.19	1.3	0.61	0.068	0.55
21	60	32	2.22	3.5	2.06	1.4	0.56	0.071	0.49
22	66	42	2.12	3.2	2.12	1.1	0.52	0.067	0.46
23	64	40	1.81	4.0	0.89	3.1	0.59	0.064	0.53
24	67	41	1.74	3.4	1.81	1.6	0.54	0.068	0.48
25	79	45	1.81	3.1	0.98	2.1	0.50	0.070	0.43
26	80	54	1.70	3.1	0.47	2.6	0.47	0.081	0.39
27	85	44	1.45	3.0	0.08	2.9	0.40	0.069	0.33
28	83	44	1.68	2.9	0.14	2.8	0.19	0.061	0.13
29	80	44	1.65	3.3	<0.010	3.3	0.38	0.056	0.33
30	84	46	1.37	4.0	0.045	4.0	0.47	0.050	0.42
31	76	51	1.07	3.4	0.064	3.3	0.22	0.045	0.18
Apr. 1	80	43	1.04	3.8	0.025	3.8	0.13	0.038	0.10
2	78	47	1.05	3.1	<0.010	3.1	0.07	0.042	0.03
3	81	51	1.19	3.3	0.058	3.2	0.11	0.001	0.11
4	85	48	1.14	1.6	0.060	1.5	0.07	0.003	0.07
5	80	40	1.26	3.0	<0.010	3.0	0.04	0.042	<0.01
6	71	39	1.26	2.6	<0.010	2.6	0.03	0.001	0.03
7	78	25	1.10	2.5	0.020	2.5	0.02	<0.001	0.02
8	78	36	1.11	2.6	0.062	2.5	0.06	0.001	0.06
9	73	36	1.23	2.5	0.052	2.4	0.07	0.006	0.07
10	58	34	1.07	2.2	0.082	2.1	0.04	<0.001	0.04
11	42	26	1.05	1.8	0.057	1.7	0.06	0.003	0.06
12	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
13	48	32	1.07	1.5	0.116	1.4	0.06	0.004	0.06
14	42	32	1.05	1.5	0.057	1.4	<0.01	<0.001	<0.01
15	38	30	1.30	1.6	0.053	1.5	0.01	0.005	<0.01
16	37	30	1.07	1.7	0.034	1.7	<0.01	0.002	<0.01
17	35	18	1.05	1.3	0.034	1.3	<0.01	0.002	<0.01
Mean	67	38	1.42	2.8	0.438	2.4	0.24	0.034	0.21
Stan. Dev.	16	9	0.41	0.8	0.720	0.9	0.23	0.031	0.21

TABLE A-55. SUMMARY DATA SHEET, AILEY, #3 FILTER EFFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
Mar. 19	24	24	39	7	3	4	8.2	6.7	6.8	6.5	18.5
20	8	1	41	5	3	4	8.4	6.8	6.9	6.7	20.0
21	15	14	42	6	3	4	7.9	7.0	6.0	6.5	17.0
22	1	<1	41	4	4	22	9.0	6.8	7.8	6.8	16.0
23	14	2	40	4	2	56	9.3	6.8	7.8	6.7	14.0
24	10	2	41	5	3	1	9.6	6.8	7.8	6.8	14.5
25	43	13	41	5	3	9	9.4	6.9	8.5	6.9	16.0
26	19	7	40	7	7	2	9.1	6.8	7.5	6.7	17.0
27	14	1	39	5	4	18	8.8	6.7	7.8	6.9	17.0
28	15	13	42	5	3	81	8.9	7.1	7.4	7.0	17.5
29	42	42	40	6	4	2	8.8	6.7	7.2	6.9	19.0
30	10	4	40	5	4	1	8.8	6.8	6.9	6.8	20.0
31	11	1	41	5	4	< 1	8.2	6.8	6.5	7.0	21.0
Apr. 1	6	1	46	4	4	< 1	7.5	7.0	5.6	7.1	20.0
2	45	1	42	3	4	11	8.4	7.0	7.5	7.1	21.0
3	7	6	44	4/4	8/7	< 1	8.3	6.8	6.4	6.8	22.0
4	10	4	42	4	4	< 1	8.0	6.9	5.9	6.9	22.5
5	13	4	42	4	3	5	7.9	6.7	6.9	6.8	20.5
6	8	2	43	3	3	< 1	9.2	7.0	7.5	6.8	18.0
7	2	1	42	3	4	< 1	9.4	7.1	8.1	6.9	18.0
8	1	<1	43	5	> 8[a]	< 1	8.4	7.1	7.4	6.8	19.5
9	1	1	41	4/4	3/4	< 1	8.0	7.0	6.6	6.8	19.0
10	17	4	44	3	3	< 1	8.7	7.0	7.6	7.0	19.5
11	19	3	48	4	> 8[a]	< 1	8.1	7.2	6.9	6.7	20.0
12	6	4	44	3	> 8[a]	< 1	8.5	7.0	7.0	6.8	21.0
13	17	10	44	3	6	< 1	8.3	7.0	7.1	6.8	21.5
14	14	10	44	3	> 9[a]	2	8.3	7.0	6.9	6.7	21.0
15	8	4	44	3	> 9[a]	< 1	8.4	7.0	6.9	6.8	21.0
16	18	14	43	3	4	1	8.3	6.7	7.4	6.8	22.0
17	15	9	44	2	6	2	8.4	6.9	7.1	6.8	23.0
Mean	14	7	42	4/4	5/5	0.3986 L	8.5	6.9	7.1	6.8	19.2
Stan. Dev.	11	9	2	1/0	2/2	0.5645 L	0.5	0.1	0.7	0.1	2.3

[a] Outside 40-70% range.

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-56. SUMMARY DATA SHEET, AILEY, #3 FILTER EFFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Mar. 19	20	9	2.90	1.4	0.546	0.9	3.9	0.029	3.9
20	17	2	1.68	1.2	0.053	1.1	2.8	0.027	2.8
21	15	6	3.07	1.4	0.079	1.3	2.8	0.038	2.8
22	30	22	1.60	0.7	0.042	0.7	2.01	0.007	2.00
23	30	23	1.38	1.1	0.013	1.1	2.30	0.020	2.28
24	30	30	1.38	1.3	0.025	1.3	2.66	0.068	2.60
25	37	28	1.39	1.4	0.026	1.4	2.17	0.019	2.15
26	37	26	1.39	1.2	0.069	1.1	2.17	0.001	2.17
27	37	30	1.41	1.0	0.016	1.0	1.94	0.008	1.93
28	37	25	1.52	1.5	0.043	1.5	2.22	0.006	2.21
29	36	26	1.36	1.7	0.010	1.7	1.72	0.009	1.71
30	34	22	1.14	1.9	<0.010	1.9	1.70	0.011	1.69
31	31	21	1.01	1.9	0.067	1.8	1.78	0.006	1.77
Apr. 1	26	22	0.89	1.6	0.021	1.6	1.08	0.014	1.07
2	32	26	0.87	1.9	0.042	1.9	1.12	0.006	1.11
3	32	28	0.96	1.5	<0.010	1.5	1.17	0.014	1.16
4	32	27	1.11	1.1	0.028	1.1	1.66	0.004	1.66
5	27	22	0.99	1.4	<0.010	1.4	1.83	0.008	1.82
6	24	22	0.99	1.0	<0.010	1.0	1.33	<0.001	1.33
7	25	22	0.92	1.2	0.030	1.2	1.21	<0.001	1.21
8	35	20		1.5	<0.010	1.5	1.66	<0.001	1.66
9	32	20	1.08	1.1	0.116	1.1	1.70	0.011	1.69
10	26	18	0.93	1.0	0.015	1.0	1.88	0.004	1.88
11	16	12	0.98	1.0	0.017	1.0	2.46	0.002	2.46
12	22	20	1.07	1.1	<0.010	1.1	1.66	0.007	1.65
13	27	20	1.04	0.9	<0.010	0.9	1.64	0.003	1.64
14	21	20	1.05	0.9	0.050	0.8	1.68	0.003	1.68
15	30	22	1.05	0.9	0.031	0.9	2.04	0.005	2.04
16	26	22	1.11	0.7	0.015	0.7	1.80	0.004	1.80
17	16	10	1.13	0.9	0.016	0.9	2.04	0.002	2.04
Mean	28	21	1.29	1.2	0.048	1.2	1.94	0.011	1.93
Stan. Dev.	7	7	0.52	0.3	0.097	0.3	0.59	0.014	0.59

TABLE A-57. SUMMARY DATA SHEET, AILEY, #4 CHLORINATED EFFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C	Daily Total Flow mgd
Mar. 19	21	21	34	3	2	<1	8.3	5.2	6.9	5.4	18.0	0.104[b]
20	4	<1	35	3	2	<1	8.8	6.7	5.8	6.3	20.5	0.104[b]
21	12	11	37	3	1	<1	8.1	6.8	5.9	6.5	19.0	0.104[b]
22	1	1	38	1	3	<1	9.1	6.7	7.7	6.5	17.0	0.129
23	14	1	35	3	1	<1	9.4	6.8	7.2	6.4	16.5	0.116
24	9	1	36	3	5	<1	9.3	6.6	7.5	6.5	15.0	0.112
25	33	7	38	4	3	<1	9.4	6.8	8.2	6.6	16.0	0.102
26	17	4	37	5	5	<1	9.0	6.7	7.7	6.6	18.0	0.096[b]
27	14	<1	34	4	4	<1	8.9	6.6	7.0	6.4	18.0	0.096[b]
28	16	15	37	2	3	<1	9.0	6.8	7.4	6.7	18.0	0.096[b]
29	41	41	36	4	5	<1	8.9	6.6	7.2	6.6	19.0	0.077
30	9	8	36	3	3	<1	8.8	6.7	6.3	6.6	20.0	0.094
31	15	2	38	3	4	1	8.2	6.8	5.8	6.6	21.0	0.058
Apr. 1	1	<1	45	4	5	<1	7.3	6.8	4.2	6.8	22.0	0.097
2	34	1	41	3	6	<1	8.5	6.8	7.0	6.8	21.0	0.088[b]
3	4	3	41	3/3	7/8	<1	8.4	6.7	6.0	6.5	22.0	0.088[b]
4	4	<1	36	4	5	<1	8.1	6.7	5.3	6.7	23.0	0.088[b]
5	17	4	39	1	2	2	7.9	6.8	6.5	6.7	22.0	0.080
6	10	1	38	2	3	<1	9.1	6.8	6.8	6.5	20.0	0.070
7	1	1	39	2	3	<1	9.2	7.0	7.5	6.6	18.0	0.058
8	<1	<1	37	3	>9[a]	<1	8.4	6.8	7.0	6.6	19.0	0.054
9	2	1	36	5/5	5/5	<1	8.1	6.9	5.9	6.4	20.0	0.054[b]
10	20	2	39	2	2	<1	8.6	6.7	7.0	6.8	20.0	0.054[b]
11	22	1	37	4	>8[a]	<1	7.9	6.8	6.1	6.6	20.0	0.054[b]
12	1	1	40	2	>8[a]	<1	8.5	6.9	6.5	6.5	21.0	0.054
13	14	5	40	2	4	<1	8.2	6.8	6.7	6.6	21.0	0.044
14	6	3	38	3	>9[a]	<1	8.2	6.9	6.3	6.5	21.5	0.040
15	1	<1	39	3	>9[a]	<1	8.3	6.8	6.0	6.5	21.5	0.038
16	15	14	38	3	5	<1	8.2	6.8	7.1	6.6	22.0	0.033[b]
17	16	11	38	3	6	2	8.4	6.8	6.8	6.6	22.0	0.033[b]
Mean	13	6	38	3/4	5/7	0.0200 L	8.5	6.7	6.6	6.5	19.7	0.077
Stan. Dev.	10	8	2	1/1	2/2	0.0763 L	0.5	0.3	0.8	0.2	2.0	0.027

[a] Outside 40-70% range.

[b] Average weekend flow.

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-58. SUMMARY DATA SHEET, AILEY, #4 CHLORINATION EFFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Mar. 19	17	11	2.90	1.4	0.013	1.4	2.5	0.002	2.5
20	16	5	1.70	1.0	0.086	0.9	2.6	0.003	2.6
21	21	8	1.68	1.0	0.015	1.0	2.4	<0.001	2.4
22	31	24	1.57	0.5	0.038	0.5	1.99	0.002	1.99
23	35	35	1.38	1.7	0.019	1.7	2.72	<0.001	2.72
24	33	33	1.39	1.3	0.067	1.2	2.16	<0.001	2.16
25	37	26	1.39	1.5	0.055	1.4	2.12	0.003	2.12
26	43	31	1.39	1.0	0.011	1.0	2.16	0.003	2.16
27	39	29	1.45	1.0	0.069	0.9	1.79	0.002	1.79
28	35	25	1.30	1.5	<0.010	1.5	2.29	<0.001	2.29
29	35	26	1.35	1.5	0.016	1.5	1.57	0.003	1.57
30	37	27	1.14	1.6	<0.010	1.6	2.21	0.015	2.20
31	35	26	0.99	1.8	<0.010	1.8	1.36	0.014	1.35
Apr. 1	28	25	0.86	1.5	0.046	1.5	1.11	0.011	1.10
2	33	26	0.77	1.3	0.038	1.3	1.53	0.005	1.53
3	32	30	0.95	1.1	0.016	1.1	2.57	0.004	2.57
4	33	29	1.08	1.0	<0.010	1.0	1.78	<0.001	1.78
5	24	22	1.02	2.1	0.018	2.1	2.14	<0.001	2.14
6	24	20	0.91	1.4	<0.010	1.4	1.75	0.012	1.74
7	24	19	0.92	0.8	0.028	0.8	1.39	<0.001	1.39
8	26	24	0.92	0.8	<0.010	0.8	2.10	<0.001	2.10
9	36	23	1.08	1.1	0.167	1.1	1.71	0.011	1.70
10	22	19	0.93	1.2	<0.010	1.2	1.90	0.003	1.90
11	15	12	0.90	0.9	0.017	0.9	2.47	0.003	2.47
12	22	22	0.98	1.0	0.014	1.0	1.70	0.013	1.69
13	22	22	0.96	0.7	<0.010	0.7	1.86	<0.001	1.86
14	21	20	0.98	0.7	0.024	0.7	1.64	<0.001	1.64
15	32	22	1.08	0.7	0.031	0.7	1.82	0.003	1.82
16	24	20	0.98	0.7	0.016	0.7	1.82	0.002	1.82
17	15	7	0.98	0.8	0.015	0.8	1.77	0.003	1.77
Mean	28	22	1.20	1.2	0.030	1.1	1.96	0.004	1.96
Stan. Dev.	8	7	0.41	0.4	0.033	0.4	0.40	0.004	0.40

TABLE A-59. SUMMARY DATA SHEET, AILEY, #1 LAGOON INFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
Sept. 15	148	131	139	82	19	7×10^6	6.4	7.7	5.7	7.8	28.0
16	115	102	146	73	23	3×10^6	5.1	7.7	5.7	7.6	27.0
17	172	131	136	80	21	10.3×10^6	7.5	7.7	3.2	7.5	26.5
18	76	74	136	61	19	3.85×10^6	7.1	7.7	5.6	7.5	29.0
19	129	109	144	61	17	4.85×10^6	7.7	7.8	5.5	7.5	27.0
20	134	94	141	96	24	3.5×10^6	6.6	7.8	4.4	7.5	28.0
21	72	67	144	56	13	5.25×10^6	5.6	7.7	4.4	7.5	27.5
22	160	142	144	87	19	4.45×10^6	7.8	7.9	6.7	7.6	27.0
23	131	111	146	60	14	5.4×10^6	7.3	7.9	5.6	7.6	27.0
24	106	90	141	57	21	4.9×10^6	7.4	7.8	4.5	7.5	26.0
25	188	160	136	85	23	4.15×10^6	8.0	7.8	4.9	7.5	27.5
26	97	86	148	71	20	4.75×10^6	7.0	7.7	5.2	7.5	26.5
27	120	87	144	47/27	14/14	5.45×10^6	6.3	7.7	4.3	7.6	27.0
28	138	113	134	44	16	4.35×10^6	6.3	7.7	6.9	7.7	25.0
29	101	95	135	52	18	5.15×10^6	6.9	7.7	6.7	7.8	26.0
30	107	85	137	67	20	5.9×10^6	6.6	7.7	5.8	7.6	27.0
Oct. 1	107	86	140	66	21	8.1×10^6	6.2	7.7	4.5	7.5	28.0
2	178	152	140	93	–	4.75×10^6	6.4	7.8	4.2	7.4	26.0
3	147	138	144	101	16	2.8×10^6	9.6	7.8	7.4	7.7	26.0
4	126	122	157	90	24	4.15×10^6	7.3	7.8	5.9	7.6	22.0
5	167	151	165	81/98	22/21	5.45×10^6	6.9	7.7	5.6	7.6	22.5
6	168	141	139	51	17	6.5×10^6	7.3	7.8	6.6	7.6	23.5
7	350	293	133	138	35	6.9×10^6	8.9	7.7	5.2	7.5	23.0
8	216	168	137	68	19	6.75×10^6	6.8	7.6	4.5	7.5	24.0
9	153	129	131	71	18	7.2×10^6	8.0	7.7	5.3	7.5	24.0
10	152	123	134	80	15	5.3×10^6	8.3	7.7	6.0	7.6	22.0
11	190	159	126	98	16	4.15×10^6	7.8	7.7	6.2	7.5	23.5
12	135	128	129	76	15	7.3×10^6	8.4	7.6	5.8	7.4	21.5
13	203	143	126	91	23	4.5×10^6	8.7	7.6	6.1	7.5	18.5
14	158	149	126	89	15	6.05×10^6	9.0	7.6	7.3	7.3	16.0
Mean	148	125	139	76/63	19/18	6.7150 L	7.3	7.7	5.5	7.5	25.1
Stan. Dev.	52	42	9	20/50	4/5	0.1250 L	1.0	0.1	1.0	0.1	3.0

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-60. SUMMARY DATA SHEET, AILEY, #1 LAGOON INFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Sept. 15	180	98	7.41	23.2	8.47	14.7	0.24	0.110	0.13
16	285	89	8.90	14.3	7.92	6.4	0.18	0.072	0.11
17	217	104	8.27	21.9	6.86	15.0	0.22	0.074	0.15
18	156	75	5.57	22.9	6.69	16.2	0.24	0.082	0.16
19	207	111	7.35	23.9	8.06	15.8	0.28	0.128	0.15
20	189	64	7.59	18.1	7.85	10.2	0.34	0.142	0.20
21	318	83	6.78	12.8	7.46	5.3	0.30	0.132	0.17
22	265	77	7.03	13.4	7.83	5.6	0.56	0.38	0.18
23	275	87	7.63	13.1	8.42	4.7	0.70	0.50	0.20
24	180	67	7.50	18.1	7.40	10.7	0.82	0.54	0.28
25	137	26	7.59	16.4	7.65	8.8	1.78	1.24	0.54
26	155	32	7.67	18.9	5.70	13.2	1.44	0.89	0.55
27	91	44	6.85	15.5	8.47	7.0	1.60	1.06	0.54
28	95	60	7.71	14.1	6.32	7.8	1.50	0.77	0.73
29	153	103	6.51	14.6	6.45	8.2	1.86	1.08	0.78
30	136	94	7.36	14.2	6.93	7.3	1.70	0.86	0.84
Oct. 1	111	66	8.93	15.2	6.89	8.3	1.94	0.92	1.02
2	152	114	7.65	15.7	7.81	7.9	3.24	1.28	1.96
3	116	95	8.08	14.6	9.65	5.0	4.4	1.64	2.8
4	132	89	8.76	15.3	9.52	5.8	2.30	0.81	1.49
5	117	108	9.62	13.4	11.64	1.8	4.8	1.78	3.0
6	121	110	7.47	13.5	8.02	5.5	4.4	1.46	2.9
7	147	102	10.31	13.7	6.70	6.0	8.2	2.91	5.3
8	108	65	7.77	14.0	6.75	7.2	5.3	1.58	3.7
9	102	69	7.80	13.6	6.15	7.4	5.4	1.26	4.1
10	112	83	8.36	14.3	7.09	7.2	6.0	1.58	4.4
11	148	94	8.24	13.9	5.35	8.6	3.7	1.27	2.4
12	133	63	8.24	13.6	5.89	7.7	4.0	0.96	3.0
13	141	73	7.30	14.1	6.27	7.8	3.9	0.87	3.0
14	144	69	8.24	13.6	4.94	8.7	3.7	0.69	3.0
Mean	161	80	7.82	15.8	7.37	8.4	2.50	0.902	1.59
Stan. Dev.	59	23	0.92	3.2	1.38	3.5	2.13	0.650	1.55

TABLE A-61. SUMMARY DATA SHEET, AILEY, #2 LAGOON EFFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
Sept. 15	42	32	97	12	6	TNTC	7.5	8.7	7.5	9.4	29.0
16	31	29	97	12	6	150	7.8	8.8	8.0	9.3	27.0
17	30	27	100	13	6	20	7.3	8.2	10.3	9.7	29.0
18	21	20	106	13	7	6	6.6	8.0	9.8	9.7	28.0
19	52	42	104	18	7	4	8.1	8.5	9.8	9.7	29.0
20	41	36	98	19	7	9	9.2	8.1	10.4	9.7	30.5
21	42	36	100	17	6	11	8.4	9.2	9.3	9.7	30.0
22	49	45	99	20	7	5	9.4	9.3	10.2	9.7	29.0
23	50	47	100	20	6	11	9.9	9.2	11.3	9.9	29.0
24	37	35	103	25	7	7	9.3	9.3	11.5	9.8	28.0
25	63	45	101	19	6	14	8.8	9.2	8.4	9.6	30.0
26	41	33	100	18	5	17	9.0	9.2	8.4	9.8	28.0
27	56	39	100	22/16	7/5	5	8.8	9.3	9.4	9.9	29.5
28	66	54	101	20	6	5	8.3	8.9	8.5	9.8	27.0
29	53	46	105	19	7	5	8.5	8.1	7.7	9.4	28.0
30	51	39	101	19	7	34	9.1	9.2	9.5	9.6	27.0
Oct. 1	52	33	106	23	6	13	7.9	9.1	10.0	9.7	28.0
2	41	38	95	23	7	11	7.1	9.0	7.2	9.5	28.0
3	63	61	111	28	7	20	8.9	8.8	9.5	9.3	25.0
4	49	46	109	29	7	9	8.8	8.6	10.2	9.4	22.5
5	30	27	113	26/21	7/7	5	8.8	8.8	10.5	9.5	24.0
6	56	44	105	14	6	7	8.2	8.8	8.7	9.3	24.0
7	63	52	108	22	7	12	7.8	8.7	11.2	9.4	23.5
8	53	12	110	16	6	9	7.5	8.7	11.4	9.4	24.0
9	45	29	107	16	6	10	7.9	8.4	10.1	9.3	24.5
10	55	51	116	21	7	4	7.3	8.4	11.1	9.4	22.5
11	51	41	113	20	7	6	7.9	8.5	11.7	9.3	23.0
12	50	42	117	34	7	6	8.0	8.3	10.7	9.1	21.0
13	73	65	112	27	7	7	9.0	8.4	10.1	9.1	18.0
14	34	29	111	18	16	7	9.5	8.4	12.6	9.2	16.0
Mean	48	39	105	20/19	7/6	0.9427 L	8.4	8.7	9.8	9.5	26.1
Stan. Dev.	12	11	6	5/4	2/1	0.3652 L	0.8	0.4	1.3	0.2	3.6

TNTC - Too numerous to count.

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-62. SUMMARY DATA SHEET, AILEY, #2 LAGOON EFFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Sept. 15	54	31	2.67	3.5	0.026	3.5	0.04	0.007	0.03
16	90	61	2.95	12.8	0.016	12.8	0.02	0.001	0.02
17	63	40	3.54	3.2	0.101	3.1	0.06	0.003	0.06
18	60	37	4.06	2.7	0.024	2.7	0.06	0.007	0.05
19	51	24	3.77	8.3	0.193	8.1	0.07	0.011	0.06
20	49	18	3.18	5.6	0.018	5.6	0.06	0.009	0.05
21	82	58	3.71	8.6	0.072	8.5	0.06	0.008	0.05
22	86	74	3.02	10.2	0.022	10.2	0.07	0.008	0.06
23	89	76	2.92	9.4	0.033	9.4	0.07	0.008	0.06
24	59	24	3.58	14.1	0.050	14.0	0.08	0.006	0.07
25	66	39	3.34	12.3	0.038	12.3	0.05	0.005	0.04
26	64	45	3.00	12.9	0.017	12.9	0.12	0.008	0.11
27	61	42	2.88	10.6	0.096	10.5	0.09	0.008	0.08
28	50	46	3.27	8.9	0.046	8.9	0.10	0.004	0.10
29	54	50	3.77	9.5	0.045	9.5	0.10	0.005	0.10
30	49	39	3.78	9.7	0.070	9.7	0.13	0.019	0.11
Oct. 1	48	39	3.54	9.2	0.056	9.2	0.11	0.004	0.11
2	52	42	3.81	9.9	0.023	9.9	0.14	0.009	0.13
3	48	38	4.30	10.2	0.060	10.1	0.08	0.016	0.06
4	41	32	4.31	9.7	0.042	9.7	0.08	0.011	0.07
5	52	48	4.16	7.9	0.072	7.8	0.08	0.013	0.07
6	50	46	3.95	8.1	0.044	8.1	0.08	0.009	0.07
7	53	45	4.04	7.6	<0.010	7.6	0.09	0.010	0.08
8	49	44	3.98	7.9	0.038	7.9	0.10	0.013	0.09
9	51	46	4.35	8.6	0.047	8.6	0.11	0.012	0.10
10	43	38	5.01	8.6	0.013	8.6	0.12	0.014	0.11
11	49	41	5.01	8.8	0.041	8.8	0.06	0.008	0.05
12	48	40	5.53	9.2	0.062	9.1	0.04	0.008	0.03
13	43	35	5.04	8.9	0.026	8.9	0.04	0.009	0.03
14	45	37	4.84	8.5	<0.010	8.5	0.06	0.009	0.05
Mean	57	43	3.84	8.8	0.047	8.8	0.08	0.009	0.07
Stan. Dev.	14	13	0.73	2.6	0.036	2.6	0.03	0.004	0.03

TABLE A-63. SUMMARY DATA SHEET, AILEY, #3 FILTER EFFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
Sept. 15	24	19	88	7	7	TNTC	8.6	7.7	6.6	7.5	28.0
16	2	2	87	5	6	TNTC	7.2	7.3	4.0	6.4	27.0
17	10	8	96	6	6	120	6.6	6.9	4.4	6.7	27.0
18	2	2	111	5	5	< 1	6.5	7.3	4.6	6.9	27.0
19	14	8	108	5	4	2	7.3	7.4	5.3	7.2	27.5
20	7	2	93	8	7	< 1	7.7	7.6	5.2	7.4	27.5
21	N.S.	N.S.	N.S.	N.S.	N.S.	2.5	N.S.	N.S.	4.9	7.4	28.0
22	15	10	95	6	6	1	8.1	7.6	5.0	7.4	27.0
23	7	5	95	5	4	1	8.5	7.7	5.7	7.5	27.0
24	4	3	95	5	5	< 1	7.8	7.6	5.7	7.5	27.0
25	N.S.	N.S.	N.S.	N.S.	N.S.	3	N.S.	N.S.	5.7	7.2	28.5
26	3	2	95	5	4	3	7.6	7.6	4.9	7.2	27.0
27	12	2	84	5/4	4/4	< 1	7.5	7.6	4.9	7.4	27.5
28	26	12	87	5	4	< 1	7.9	7.6	5.9	7.5	26.5
29	12	9	88	5	5	< 1	8.0	7.5	6.4	7.5	27.5
30	14	10	93	5	3	< 1	8.0	7.6	6.8	7.3	26.5
Oct. 1	12	1	92	4	4	< 1	7.7	7.6	6.4	7.4	27.0
2	11	8	90	9	6	< 1	7.4	7.6	5.6	7.4	26.0
3	14	11	95	5	4	< 1	7.8	7.4	5.8	7.5	25.0
4	5	4	98	5	4	< 1	8.4	7.4	5.7	7.5	22.5
5	3	1	109	6/5	4/4	< 1	8.0	7.5	5.9	7.4	24.0
6	16	7	107	4	4	< 1	7.8	7.6	6.8	7.5	24.0
7	7	3	99	6	4	1.5	7.1	7.5	4.0	7.6	23.5
8	15	2	89	5	4	< 1	7.5	7.3	4.0	7.2	25.0
9	15	9	91	5	4	3.5	7.2	7.4	4.8	7.3	25.0
10	7	6	95	3	4	< 1	7.6	7.5	5.1	7.4	23.0
11	11	2	95	4	4	< 1	7.7	7.5	4.8	7.3	24.0
12	5	2	99	4	3	< 1	8.1	7.5	4.5	7.1	22.0
13	18	15	104	5	5	1	8.5	7.5	4.9	7.4	19.0
14	9	8	109	4	3	< 1	8.8	7.4	5.2	7.2	20.0
Mean	11	6	96	5/5	5/4	0.1430 L	7.7	7.5	5.3	7.3	25.6
Stan. Dev.	6	5	7	1/1	1/0	0.4031 L	0.6	0.2	0.8	0.3	2.4

N.S. - No sample.

TNTC - Too numerous to count.

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-64. SUMMARY DATA SHEET, AILEY, #3 FILTER EFFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Sept. 15	36	13	2.76	3.3	0.065	3.2	3.36	0.156	3.20
16	39	22	2.66	4.1	0.040	4.1	3.48	0.210	3.27
17	46	23	1.95	2.1	0.185	1.9	3.14	0.098	3.04
18	50	19	1.73	2.0	<0.010	2.0	2.42	0.093	1.53
19	43	12	2.07	3.6	<0.010	3.6	2.20	0.081	2.12
20	32	8	2.77	3.8	0.023	3.8	1.87	0.055	1.81
21	36	23	2.66	3.3	N.S.	N.S.	N.S.	N.S.	N.S.
22	47	29	2.54	3.1	0.063	3.0	1.24	0.043	1.20
23	46	24	2.61	2.9	0.138	2.8	1.48	0.052	1.43
24	31	8	2.71	2.8	0.173	2.6	1.92	0.049	1.87
25	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
26	18	7	2.76	4.1	0.08	4.0	6.75	0.124	6.63
27	24	9	2.81	3.9	0.35	3.6	3.78	0.128	3.65
28	38	33	2.71	5.6	0.024	5.6	4.04	0.069	3.97
29	35	32	3.05	6.1	0.010	6.1	2.94	0.044	2.94
30	34	27	2.95	5.5	0.036	5.5	2.14	0.041	2.10
Oct. 1	35	30	2.96	5.8	0.035	5.8	2.02	0.041	1.98
2	33	17	2.85	6.2	0.080	6.1	2.54	0.056	2.48
3	38	14	3.16	6.2	0.028	6.2	2.48	0.041	2.44
4	30	15	3.40	7.3	0.106	7.2	2.56	0.037	2.52
5	34	29	3.52	5.9	0.077	5.8	2.96	0.048	2.91
6	28	24	3.71	5.9	0.169	5.7	3.42	0.070	3.35
7	34	30	3.54	5.5	0.123	5.4	2.90	0.064	2.84
8	22	15	3.66	5.7	0.119	5.6	4.6	0.065	4.5
9	22	15	3.70	6.4	0.151	6.2	4.8	0.059	4.7
10	29	17	3.71	6.4	0.092	6.3	4.7	0.060	4.6
11	30	21	4.18	5.7	0.046	5.7	4.5	0.046	4.5
12	24	17	4.18	5.8	0.142	5.7	3.9	0.051	3.8
13	25	21	4.30	5.4	0.017	5.4	3.4	0.024	3.4
14	29	12	4.25	5.0	0.042	5.0	2.9	0.019	2.9
Mean	33	20	3.10	4.8	0.087	4.8	3.16	0.069	3.06
Stan. Dev.	8	8	0.68	1.5	0.075	1.5	1.20	0.042	1.21

N.S. - No sample.

TABLE A-65. SUMMARY DATA SHEET, AILEY, #4 CHLORINATED EFFLUENT (FIELD)

1977 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C	Daily Flow mgd
Sept. 15	25	13	81	4	5	< 1	9.2	7.7	7.3	7.4	28.0	0.026
16	1	1	80	4	6	< 1	9.3	7.5	7.0	7.1	27.0	0.021
17	1	1	78	5	4	< 1	8.9	7.5	6.4	7.0	28.0	0.046
18	1	1	88	5	7	< 1	8.7	7.5	6.9	7.2	27.5	0.049
19	10	5	88	6	6	< 1	9.3	7.5	7.3	7.0	27.0	0.041
20	7	4	81	5	7	< 1	9.2	7.5	7.6	7.2	27.0	0.050
21	13	5	84	4	4	< 1	8.7	7.7	7.1	7.2	28.0	0.018
22	10	8	86	5	5	< 1	9.8	7.6	7.5	7.2	27.0	0.045
23	3	2	85	4	4	< 1	9.8	7.5	8.0	7.3	26.0	0.019
24	2	2	85	4	4	< 1	9.3	7.5	7.3	7.2	26.5	0.027
25	19	1	87	4	5	< 1	9.4	7.7	7.3	7.2	27.5	0.038
26	2	1	80	3	4	< 1	9.1	7.5	7.3	7.0	26.5	0.020
27	6	1	81	4/4	4/4	< 1	9.5	7.6	7.4	7.2	27.0	0.024
28	13	8	82	3	5	< 1	9.4	7.6	6.9	7.2	26.5	0.031
29	10	9	80	5	4	< 1	8.9	7.5	7.1	7.3	27.0	0.030
30	7	1	90	4	3	1	9.5	7.6	7.4	7.2	26.5	0.032
Oct. 1	6	1	92	5	4	< 1	8.9	7.7	6.7	7.4	27.0	0.040
2	8	6	89	5	6	< 1	8.3	7.4	6.6	7.4	27.0	0.032
3	8	7	98	5	5	< 1	9.3	7.4	6.9	7.2	25.0	0.028
4	2	1	92	3	4	< 1	10.0	7.5	7.7	7.3	23.0	0.031
5	2	1	99	4/5	4/4	< 1	9.5	7.5	7.1	7.1	24.0	0.023
6	17	5	97	3	3	1	9.6	7.6	7.5	7.2	23.5	0.021
7	10	3	90	3	3	< 1	9.5	7.6	6.9	7.4	23.5	0.021
8	8	2	87	3	4	< 1	9.3	7.4	7.0	7.2	25.0	0.012
9	11	8	89	4	3	< 1	9.2	7.5	7.0	7.3	25.0	0.020
10	7	5	89	3	3	< 1	9.6	7.4	7.2	7.4	22.5	0.020
11	10	4	90	5	3	< 1	9.6	7.5	7.1	7.3	23.5	0.019
12	3	1	93	3	3	< 1	9.8	7.5	7.4	7.2	22.0	0.021
13	21	17	96	4	3	< 1	10.0	7.5	7.9	7.2	19.5	0.030
14	8	6	96	4	4	< 1	10.5	7.5	7.9	7.2	20.0	0.021
Mean	8	4	88	4/5	4/4	0.0000 L	9.4	7.5	7.2	7.2	25.5	0.029
Stan. Dev.	6	4	6	1/1	1/0	0.0000 L	0.4	0.1	0.4	0.1	2.3	0.010

N.S. - No sample

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-66. SUMMARY DATA SHEET, AILEY, #4 CHLORINATED EFFLUENT (UWRL)

1977 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Sept. 15	28	13	1.87	1.1	0.086	1.0	2.92	0.026	2.89
16	31	7	2.51	2.8	0.027	2.8	3.56	0.016	3.54
17	41	18	2.74	1.3	0.081	1.2	1.90	0.012	1.89
18	38	12	2.89	0.4	0.042	0.4	0.95	0.013	0.94
19	27	2	3.08	1.5	0.017	1.5	1.52	0.044	1.48
20	23	6	2.67	0.5	0.022	0.5	1.63	0.020	1.61
21	25	3	2.51	2.2	0.022	2.2	1.42	0.008	1.41
22	28	10	2.19	1.3	0.023	1.3	1.61	0.013	1.60
23	29	19	2.24	2.0	0.023	2.0	1.69	0.015	1.67
24	24	7	2.23	2.4	0.063	2.3	1.75	0.021	1.73
25	26	3	2.09	3.4	0.024	3.4	1.66	0.009	1.65
26	17	2	2.40	2.3	0.081	2.2	3.80	0.007	3.79
27	11	3	2.07	3.0	0.33	2.7	3.50	0.007	3.49
28	23	16	2.38	3.2	0.017	3.2	1.59	0.015	1.58
29	22	11	2.77	2.7	0.016	2.7	2.64	0.006	2.63
30	19	13	2.76	2.5	0.080	2.4	2.18	0.010	2.17
Oct. 1	18	10	2.58	3.2	0.064	3.1	1.98	0.030	1.95
2	15	9	2.75	2.6	<0.010	2.6	2.42	0.056	2.36
3	14	8	2.92	3.2	<0.010	3.2	2.14	0.021	2.12
4	18	9	2.73	3.4	0.033	3.4	1.97	0.003	1.97
5	21	12	2.10	3.2	0.023	3.2	2.28	0.004	2.28
6	24	16	2.71	3.0	0.019	3.0	2.54	0.007	2.53
7	15	10	2.23	3.0	0.016	3.0	1.91	0.006	1.90
8	18	14	2.75	3.0	0.019	3.0	2.94	0.011	2.93
9	19	14	2.70	3.4	0.023	3.4	2.88	0.010	2.87
10	18	15	2.65	3.6	0.061	3.5	2.70	0.005	2.69
11	22	12	3.02	3.4	0.032	3.4	3.5	0.008	3.5
12	21	6	2.82	3.2	0.021	3.2	2.7	0.005	2.7
13	21	9	3.48	3.6	0.014	3.6	2.9	0.007	2.9
14	20	8	3.31	3.2	<0.010	3.2	1.73	0.010	1.72
Mean	23	10	2.60	2.6	0.044	2.6	2.30	0.014	2.28
Stan. Dev.	7	5	0.38	0.9	0.059	0.9	0.73	0.012	0.73

TABLE A-67. SUMMARY DATA SHEET, AILEY, #1 LAGOON INFLUENT (FIELD)

1978 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
Jan. 4	83	46	118	79	23	3.5×10^5	9.2	7.5	9.1	7.7	15.0
5	59	38	110	112	31	3.0×10^5	8.3	7.3	8.4	7.3	15.0
6	64	60	130	81	24	2.5×10^5	8.6	7.5	8.5	7.3	15.0
7	23	15	108	46	19	3.0×10^5	8.6	7.3	6.9	7.1	17.0
8	93	90	112	148	33	9.0×10^5	8.1	7.5	6.4	7.1	16.5
9	124	112	97	115	18	1.05×10^6	8.2	7.3	8.7	7.1	10.0
10	56	49	87	78	17	6.0×10^5	10.4	7.3	9.1	7.1	10.0
11	122	58	86	75	17	5.5×10^5	9.3	7.3	8.3	7.2	12.5
12	66	46	101	94	24	6.0×10^5	8.7	7.2	7.1	6.9	12.0
13	146	142	92	77	14	9.5×10^5	8.5	7.3	8.4	6.6	10.5
14	1489	1446	67	80	14	1.15×10^6	8.2	7.2	7.0	6.7	6.0
15	481	457	67	98	12	1.4×10^6	8.9	7.2	8.3	6.9	12.0
16	434	412	69	83/6	3^b/14	1.35×10^6	8.1	7.2	7.1	6.9	14.0
17	58	39	73	69	16	1.3×10^6	7.9	7.5	7.3	6.8	16.0
18	79	71	71	55	14	1.45×10^6	8.5	7.2	7.9	6.9	14.0
19	92	90	72	59	14	1.5×10^6	8.8	6.7	9.5	7.0	10.0
20	28	12	67	39^b	17	9.0×10^5	9.7	7.1	9.5	6.9	10.0
21	45	34	64	44	13	1.0×10^6	10.0	7.0	7.9	6.5	12.0
22	20	2	64	33^b/36^b	13/11^b	1.5×10^6	9.9	7.1	8.5	6.7	12.5
23	43	36	63	34^b	13	1.15×10^6	9.6	7.3	8.5	6.7	13.5
24	53	40	61	39	16	8.0×10^5	8.1	7.1	8.1	6.7	15.0
25	66	64	59	44	26	6.5×10^5	8.1	7.3	8.1	6.9	17.0
26	46	43	63	43	26	6.5×10^5	10.4	7.3	9.7	6.7	10.0
27	65	59	59	32^b	17	6.5×10^5	11.0	7.1	9.6	7.0	10.5
28	22	17	57	31^b	17	6.0×10^5	10.5	7.5	10.0	7.1	10.0
29	45	22	56	29^b	23	5.5×10^5	11.0	7.1	9.3	6.9	9.0
30	32	18	57	30^b	11^b	6.5×10^5	10.5	7.1	9.0	6.9	11.0
31	40	26	58	25^b	11	9.0×10^5	9.6	7.0	8.7	6.8	12.0
Feb. 1	74	59	57	40	12	6.5×10^5	9.0	7.0	7.9	7.1	11.0
2	36	28	57	72	11	4.5×10^5	9.8	7.1	9.8	7.4	9.0
Mean	65	52	77	63/49	18/13	5.8740 L	9.2	7.2	8.4	7.0	12.3
Stan. Dev.	35	36	22	31/19	6/2	0.2183 L	1.0	0.2	1.0	0.3	2.7

[b] Outside the 20-80 colony limit.

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-68. SUMMARY DATA SHEET, AILEY, #1 LAGOON INFLUENT (UWRL)

1978 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Jan. 4	180	113	9.59	13.9	5.33	8.6	0.38	0.069	0.31
5	213	153	11.14	14.2	4.09	10.1	0.44	0.072	0.37
6	217	150	11.21	14.6	6.78	7.8	0.43	0.081	0.35
7	195	149	9.12	14.5	4.26	10.2	0.51	0.080	0.43
8	185	143	9.92	14.4	5.87	8.5	0.33	0.067	0.26
9	163	124	3.71	13.9	3.17	10.7	0.81	0.112	0.70
10	235	148	3.40	14.1	3.99	10.1	1.06	0.132	0.93
11	191	120	3.27	15.1	2.49	12.6	0.98	0.124	0.86
12	132	110	4.25	14.2	3.39	10.8	0.95	0.130	0.82
13	151	124	2.95	15.2	4.24	11.0	1.20	0.150	1.05
14	180	149	2.73	14.7	3.04	11.7	1.74	0.178	1.56
15	129	104	2.10	15.1	3.26	11.8	1.81	0.188	1.62
16	215	125	2.43	13.9	6.39	7.5	1.75	0.188	1.56
17	201	145	2.26	14.6	5.59	9.0	1.59	0.186	1.40
18	252	157	2.33	14.8	5.55	9.3	1.55	0.188	1.36
19	234	193	2.95	14.6	4.33	10.3	1.55	0.152	1.40
20	225	177	2.66	14.7	3.11	11.4	1.89	0.122	1.77
21	226	147	2.66	13.6	2.52	11.1	2.36	0.148	2.21
22	219	153	2.13	14.8	2.94	11.9	2.36	0.154	2.21
23	205	112	2.28	15.1	4.12	11.0	2.28	0.158	2.12
24	179	145	2.08	14.6	3.54	11.1	2.12	0.170	1.95
25	244	179	2.41	14.8	4.00	10.8	1.84	0.158	1.68
26	219	143	2.83	15.5	3.04	12.5	1.66	0.106	1.55
27	213	124	2.47	15.1	2.70	12.4	1.95	0.108	1.84
28	207	149	2.63	15.5	2.75	12.8	1.84	0.114	1.73
29	219	137	2.31	15.6	4.46	11.1	1.84	0.112	1.73
30	239	175	2.19	15.3	2.26	13.0	1.95	0.122	2.83
31	215	126	2.16	15.2	2.62	12.6	2.30	0.136	2.16
Feb. 1	205	110	2.41	15.4	2.94	12.5	2.34	0.150	2.19
2	204	95	2.38	14.9	3.06	11.8	2.30	0.138	2.16
Mean	203	139	3.90	14.7	3.86	10.9	1.54	0.133	1.44
Stan. Dev.	30	24	2.93	0.5	1.23	1.5	0.67	0.037	0.69

TABLE A-69. SUMMARY DATA SHEET, AILEY, #2 LAGOON EFFLUENT (FIELD)

1978 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
Jan. 4	47	20	116	> 42[a]	17[a]	20	12.7	9.0	14.1	9.0	12.0
5	61	49	111	> 42[a]	14[a]	65	12.4	9.3	13.7	9.3	12.0
6	68	65	105	> 44[a]	14[a]	55	12.0	9.0	13.3	9.2	12.0
7	108	85	108	> 41[a]	16[a]	35	11.6	9.1	11.9	8.3	14.0
8	31	19	105	36[a]	13[a]	38	10.4	9.1	10.5	8.9	15.0
9	51	44	100	48	19	75	11.3	8.6	12.0	9.0	8.0
10	44	31	101	45	15	100	12.6	8.5	13.3	8.7	7.0
11	67	49	100	46	17	75	12.2	8.9	13.0	9.3	9.0
12	36	28	101	43	16	175	12.8	8.9	13.0	8.9	7.0
13	41	34	106	40	14	295	12.6	8.7	12.6	8.9	8.0
14	72	51	101	47	15	355	12.1	8.4	12.9	8.7	4.0
15	115	99	104	46	15	493	12.8	8.4	13.0	8.9	7.0
16	194	182	106	38/42	13/14	445	12.4	8.4	13.0	8.9	8.0
17	42	33	101	42	16	350	11.9	8.2	12.2	8.7	11.0
18	47	31	100	39	17	315	11.2	7.7	12.4	8.9	11.5
19	31	29	106	35	19	370	11.3	8.0	11.8	8.3	8.0
20	24	22	101	36	16	500	11.2	7.7	11.6	8.0	7.5
21	35	26	99	28[a]	15	750	11.6	7.7	11.8	8.1	9.0
22	30	24	99	21[a]/37	15/16	560	11.0	7.7	11.6	7.9	9.0
23	29	26	96	22[a]	14	100	11.4	7.7	11.7	8.0	10.0
24	33	23	95	25[a]	13	70	10.7	7.6	10.3	8.0	13.0
25	28	26	91	21[a]	12	140	9.5	7.7	9.1	7.7	16.0
26	12	8	89	22[a]	10	110	11.4	7.5	11.9	7.9	9.0
27	38	33	91	34[a]	10[a]	140	12.4	7.7	12.5	8.3	9.0
28	27	26	88	23	11	130	12.3	7.8	13.3	8.4	8.5
29	32	12	88	24	22	360	12.8	7.7	13.8	8.5	7.0
30	38	18	87	27	9[a]	220	12.8	8.1	13.3	8.8	7.5
31	31	17	88	20	10[a]	110	12.6	7.6	12.3	8.7	9.5
Feb. 1	52	43	86	18[a]	9[a]	60	12.2	8.3	12.4	8.9	9.0
2	16	11	89	20[a]	10[a]	60	12.5	8.4	12.4	8.9	7.5
Mean	49	39	99	34/40	14/15	2.1720 L	11.9	8.2	12.4	8.6	9.5
Stan. Dev.	36	34	8	10/4	3/1	0.4164 L	0.8	0.6	1.1	0.5	2.7

[a] Outside the 40-70% limit.

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-70. SUMMARY DATA SHEET, AILEY, #2 LAGOON EFFLUENT (UWRL)

1978 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Jan. 4	44	40	4.45	9.1	0.174	8.9	0.13	0.023	0.11
5	47	43	4.60	9.3	0.157	9.1	0.17	0.023	0.15
6	45	40	4.33	9.9	0.250	9.7	0.07	0.021	0.05
7	49	45	4.28	9.5	0.980	8.5	0.07	0.024	0.05
8	47	40	4.36	9.6	0.116	9.5	0.08	0.023	0.06
9	43	34	4.17	9.0	0.231	8.8	0.10	0.024	0.08
10	51	46	4.51	10.1	0.271	9.8	0.13	0.025	0.10
11	51	42	4.40	10.7	0.810	9.9	0.16	0.028	0.13
12	49	45	4.41	10.4	0.830	9.6	0.17	0.029	0.14
13	46	42	4.32	10.1	0.970	9.1	0.17	0.029	0.14
14	48	41	4.35	11.3	1.400	9.9	0.18	0.030	0.15
15	45	41	4.41	11.2	1.28	9.9	0.20	0.029	0.17
16	52	45	4.21	10.3	1.57	8.7	0.23	0.031	0.20
17	51	47	4.20	10.7	1.55	9.2	0.26	0.032	0.23
18	49	41	4.13	10.6	1.56	9.0	0.29	0.034	0.26
19	49	47	3.98	10.7	1.62	9.1	0.31	0.036	0.27
20	55	41	4.02	9.9	1.59	8.3	0.33	0.037	0.29
21	47	36	3.97	9.7	2.16	7.5	0.37	0.043	0.33
22	52	42	4.02	10.6	2.22	8.4	0.39	0.052	0.34
23	53	39	4.11	10.6	2.74	7.9	0.31	0.060	0.25
24	47	37	4.11	10.7	2.50	8.2	0.36	0.071	0.29
25	52	40	4.05	10.3	2.53	7.8	0.35	0.070	0.28
26	47	42	3.76	9.9	2.62	7.3	0.35	0.065	0.28
27	52	44	3.79	10.1	2.68	7.4	0.41	0.064	0.35
28	47	39	3.72	10.5	2.48	8.0	0.41	0.061	0.35
29	49	47	3.63	12.0	2.37	9.6	0.42	0.058	0.36
30	52	41	3.27	11.1	2.02	9.1	0.46	0.059	0.40
31	53	42	3.21	10.7	1.74	9.0	0.52	0.065	0.46
Feb. 1	48	40	3.00	11.3	1.66	9.6	0.56	0.062	0.50
2	48	37	3.19	11.1	1.58	9.5	0.61	0.063	0.55
Mean	49	43	4.03	10.4	1.49	8.9	0.29	0.042	0.24
Stan. Dev.	3	9	0.42	0.7	0.85	0.8	0.15	0.018	0.13

TABLE A-71. SUMMARY DATA SHEET, AILEY, #3 FILTER EFFLUENT (FIELD)

1978 Date		SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C
Jan.	4	26	3	103	>17[a]	11	3	11.8	7.1	10.8	7.5	14.0
	5	32	15	99	14[a]	7	2	10.6	7.3	8.9	7.7	15.5
	6	44	42	118	15[a]	8	7	10.7	7.3	8.9	7.5	12.0
	7	42	24	100	13[a]	8	< 1	10.5	7.0	8.9	7.3	14.0
	8	8	5	99	16[a]	6	103	10.0	7.2	8.4	7.0	15.5
	9	16	5	93	18	12	23	10.7	7.3	9.7	7.5	10.0
	10	27	13	100	16	8	150	11.9	7.2	9.3	7.0	9.0
	11	13	8	93	16	8	5	11.4	7.2	10.1	7.7	10.0
	12	6	4	100	16	7	5	11.9	7.3	10.1	7.2	9.0
	13	7	6	94	15	7	82	12.2	7.2	11.0	7.3	9.0
	14	36	14	91	18	7	123	11.7	7.5	11.6	7.3	4.0
	15	20	5	96	19	7[a]	97	12.2	7.5	11.1	7.4	8.0
	16	27	20	100	21/19	7/9	54	11.6	7.4	10.2	7.3	10.0
	17	19	12	101	22	10	85	11.1	7.7	10.1	7.1	12.0
	18	18	16	100	17	11	77	10.6	7.4	10.4	7.3	11.5
	19	10	6	94	15	9	73	11.0	7.1	9.6	7.0	10.0
	20	5	1	93	18	9	91	10.8	7.2	9.7	6.9	10.0
	21	25	14	96	14	9	119	11.7	7.2	9.9	6.9	11.0
	22	10	4	92	13/8[a]	10/9	21	10.2	7.3	9.5	6.9	11.0
	23	15	9	91	11	6	25	11.2	7.3	8.6	6.8	12.0
	24	16	3	89	10	8	< 1	9.6	7.3	8.6	6.7	12.5
	25	28	22	79	12	6	46	9.2	7.4	8.1	6.8	17.0
	26	2	1	78	16	11[a]	4	10.4	7.1	9.1	6.6	11.0
	27	18	14	75	15	9	8	11.5	7.0	10.4	6.8	10.0
	28	12	10	80	13	8	16	10.8	7.3	9.8	6.8	9.0
	29	17	1	78	9[a]	8	24	11.6	7.2	10.4	7.0	9.0
	30	23	7	74	9[a]	8[a]	10	11.7	7.2	10.4	7.0	8.0
	31	13	1	77	8[a]	10	34	11.1	7.1	9.7	7.3	11.5
Feb.	1	28	21	73	7[a]	6[a]	46	10.8	7.2	9.9	7.5	10.0
	2	3	2	75	9[a]	6[a]	8	10.9	7.3	9.0	7.1	9.0
Mean		19	10	91	14/13	8/9	1.3190 L	11.0	7.3	9.7	7.1	10.8
Stan. Dev.		11	9	11	4/8	2/0	0.6497 L	0.7	0.2	0.9	0.3	2.6

[a] Outside the 40-70% limit.

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-72. SUMMARY DATA SHEET, AILEY, #3 FILTER EFFLUENT (UWRL)

1978 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Jan. 4	27	23	4.02	5.2	0.183	5.0	1.60	0.050	1.55
5	25	22	3.83	5.0	0.292	4.7	1.55	0.060	1.49
6	24	21	3.83	5.4	0.188	5.2	1.90	0.065	1.84
7	39	34	3.85	5.6	0.215	5.4	2.15	0.010	2.14
8	43	36	3.85	6.2	0.193	6.0	2.70	0.010	2.69
9	27	23	3.67	5.3	0.355	4.9	1.84	0.074	1.77
10	28	25	3.83	6.0	0.266	5.7	1.80	0.061	1.74
11	32	25	3.83	6.3	0.74	5.6	1.72	0.076	1.64
12	28	22	3.86	5.9	0.36	5.5	1.64	0.080	1.56
13	28	23	3.76	6.3	0.66	5.6	1.31	0.070	1.24
14	39	32	3.87	6.7	0.75	5.9	1.24	0.071	1.17
15	32	25	3.98	6.7	1.18	5.5	1.28	0.070	1.21
16	39	26	3.85	6.1	1.44	4.7	1.39	0.086	1.30
17	36	28	3.73	6.2	1.23	5.0	1.88	0.170	1.71
18	41	32	3.77	6.0	1.43	4.6	2.75	0.190	2.56
19	44	30	3.56	7.2	1.25	5.9	2.75	0.185	2.56
20	43	29	3.41	6.1	1.32	4.8	1.70	0.150	1.55
21	33	28	3.70	5.0	1.63	3.4	1.97	0.180	1.79
22	33	26	3.66	5.5	1.82	3.7	1.97	0.185	1.78
23	39	26	3.69	6.8	2.06	4.7	1.84	0.205	1.64
24	32	25	3.95	7.2	2.45	4.7	2.16	0.300	1.86
25	33	30	3.69	6.3	1.89	4.4	3.55	0.275	3.27
26	36	25	3.48	7.1	1.56	5.5	4.25	0.335	3.91
27	37	28	3.56	6.9	1.50	6.4	3.65	0.235	3.41
28	34	28	3.30	7.1	1.48	5.6	2.95	0.185	2.76
29	36	30	2.85	7.3	1.32	6.0	2.95	0.165	2.79
30	42	24	2.98	7.2	1.04	6.2	2.70	0.160	2.54
31	41	23	3.00	6.7	1.13	5.6	2.75	0.150	2.60
Feb. 1	32	26	3.00	7.4	1.14	6.3	2.75	0.145	2.60
2	28	25	2.89	7.1	0.99	6.1	2.45	0.145	2.30
Mean	35	27	3.61	6.3	1.07	5.3	2.24	0.138	2.10
Stan. Dev.	6	4	0.34	0.7	0.62	0.7	0.75	0.082	0.70

TABLE A-73. SUMMARY DATA SHEET, AILEY, #4 CHLORINATED EFFLUENT (FIELD)

1978 Date	SS mg/l	VSS mg/l	Alk mg/l as $CaCO_3$	Total BOD	Soluble BOD	Fecal Coliform Colonies/100 ml	D.O. Composite Sample mg/l	pH Composite Sample	D.O. In Situ mg/l	pH In Situ	Temperature In Situ °C	Daily Total Flow mgd
Jan. 4	26	9	102	13	8	< 1	10.8	6.9	10.4	7.1	13.5	0.074
5	29	16	94	11	6[a]	< 1	10.6	7.2	9.4	7.2	13.0	0.059
6	38	30	94	15[a]	6	< 1	10.8	7.2	9.3	6.7	12.5	0.060
7	25	17	89	9	7	< 1	10.5	7.1	8.7	6.9	14.0	0.060
8	6	4	89	9	5	< 1	10.3	7.3	8.8	6.9	15.5	0.060
9	17	2	81	9	8	1	10.7	7.3	9.8	7.0	10.5	0.107
10	14	11	84	11	8	< 1	11.3	7.5	10.0	6.7	9.0	0.075
11	16	10	81	11	6	< 1	11.5	7.3	10.2	7.0	10.5	0.071
12	3	1	84	11	6	< 1	11.9	7.3	10.3	6.9	9.0	0.070
13	6	4	86	10	5	< 1	11.8	7.3	10.7	6.9	8.0	0.117
14	31	2	87	13	7	< 1	11.3	7.3	11.6	7.1	5.0	0.126
15	17	3	89	14	8	< 1	11.9	7.3	11.1	7.0	8.0	0.103
16	24	18	89	16/15	8/9	1	11.5	7.3	10.1	6.9	10.0	0.097
17	20	16	93	15	10	< 1	11.3	7.5	9.8	7.1	12.0	0.069
18	24	18	98	15	9	< 1	10.7	7.3	10.4	6.9	10.5	0.091
19	4	1	85	12	8	< 1	11.1	7.1	9.6	6.8	10.0	0.119
20	8	1	83	13	8	< 1	11.0	7.2	9.9	6.8	9.5	0.144
21	22	7	82	10	8	< 1	11.9	7.3	10.6	6.8	10.0	0.118
22	9	5	85	10/10	7/7	< 1	10.5	7.3	9.4	6.7	11.0	0.140
23	16	6	83	7	5	< 1	11.2	7.3	8.9	6.7	10.0	0.125
24	11	6	82	8	8	< 1	10.4	7.3	8.7	6.6	13.0	0.065
25	20	16	72	8	10	< 1	9.7	7.5	8.1	6.7	16.5	0.129
26	1	1	71	8	5[a]	< 1	9.9	7.5	9.5	6.5	11.0	0.084
27	26	20	69	10	5[a]	< 1	10.8	7.0	10.7	6.7	9.5	0.129
28	10	8	69	6[a]	4[a]	< 1	11.3	7.0	9.5	6.7	9.0	0.139
29	19	2	68	6[a]	4[a]	< 1	11.6	7.1	11.0	6.8	8.0	0.145
30	22	6	65	7[a]	7[a]	< 1	11.4	7.1	10.4	6.7	8.5	0.138
31	15	1	63	5[a]	4[a]	< 1	11.0	7.1	9.3	6.6	10.5	0.143
Feb. 1	19	16	58	10[a]	4[a]	< 1	10.8	7.1	8.7	6.8	9.0	0.135
2	1	1	58	6[a]	5[a]	1	10.8	7.5	9.3	6.7	9.0	0.149
Mean	17	9	81	10/13	7/8	0.0000 L	11.0	7.2	9.8	6.8	10.5	0.105
Stan. Dev.	9	8	11	3/4	2/1	0.0000 L	0.6	0.2	0.8	0.2	2.4	0.032

[a] Outside the 40-70% limit.

/ - BOD_5/BOD_5 with nitrification inhibitor.

L = Log_{10}

TABLE A-74. SUMMARY DATA SHEET, AILEY, #4 CHLORINATED EFFLUENT (UWRL)

1978 Date	Total COD mg/l	Soluble COD mg/l	Total P mg P/l	TKN mg N/l	NH_3-N mg N/l	Org N mg N/l	(NO_3+NO_2)-N mg N/l	NO_2-N mg N/l	NO_3-N mg N/l
Jan. 4	23	20	4.02	2.6	0.113	2.5	1.45	0.005	1.45
5	22	18	3.54	2.5	0.102	2.4	1.50	0.005	1.50
6	20	14	3.54	2.5	0.066	2.4	1.85	0.010	1.84
7	23	18	3.64	2.7	0.097	2.6	1.95	0.010	1.94
8	31	24	3.60	2.2	0.107	2.1	2.65	0.015	2.64
9	23	19	3.60	3.0	0.082	2.9	1.85	0.003	1.85
10	21	16	3.83	3.1	0.092	3.0	1.74	0.003	1.74
11	20	14	3.54	2.9	0.229	2.7	1.63	0.005	1.62
12	21	15	3.65	2.7	0.224	2.5	1.56	0.006	1.55
13	19	14	3.67	3.2	0.266	2.9	1.29	0.005	1.28
14	19	14	3.83	2.9	0.74	2.2	1.21	0.005	1.20
15	20	16	3.97	2.9	0.86	2.0	1.23	0.006	1.22
16	26	17	3.77	2.7	1.21	1.5	1.34	0.009	1.33
17	25	21	3.77	2.5	1.23	1.3	1.78	0.056	1.72
18	33	17	3.75	2.8	1.38	1.4	2.75	0.145	2.60
19	41	18	3.54	3.1	1.10	2.0	2.65	0.008	2.64
20	32	15	3.44	2.1	1.27	0.8	1.70	0.006	1.69
21	27	18	3.49	2.2	1.48	0.7	1.93	0.008	1.92
22	26	16	3.52	2.6	1.85	0.7	1.90	0.008	1.89
23	25	21	3.67	3.1	1.98	1.1	1.82	0.006	1.81
24	22	12	3.72	2.9	1.82	1.1	3.75	0.012	2.74
25	17	15	3.84	2.5	1.62	0.9	3.65	0.006	3.64
26	18	13	3.63	3.6	1.43	2.2	4.45	0.013	4.44
27	25	15	3.51	2.7	1.41	1.3	3.50	0.004	3.50
28	23	15	3.45	2.9	1.36	1.5	2.90	0.003	2.90
29	25	15	3.63	2.8	1.43	1.4	2.85	0.003	2.85
30	30	15	3.00	2.5	1.15	1.3	2.70	0.006	2.69
31	24	17	2.92	2.9	0.37	2.5	2.65	0.005	2.64
Feb. 1	20	16	2.89	2.8	0.40	2.4	2.55	0.003	2.55
2	23	13	2.86	3.8	0.45	3.3	2.35	0.003	2.35
Mean	24	16	3.56	2.8	0.86	1.9	2.24	0.013	2.19
Stan. Dev.	5	3	0.29	0.4	0.64	0.8	0.83	0.027	0.78

APPENDIX B

COMPARISON OF PERFORMANCE OF SLOW SAND FILTER OPERATION WITH INTERMITTENT SAND FILTER OPERATION

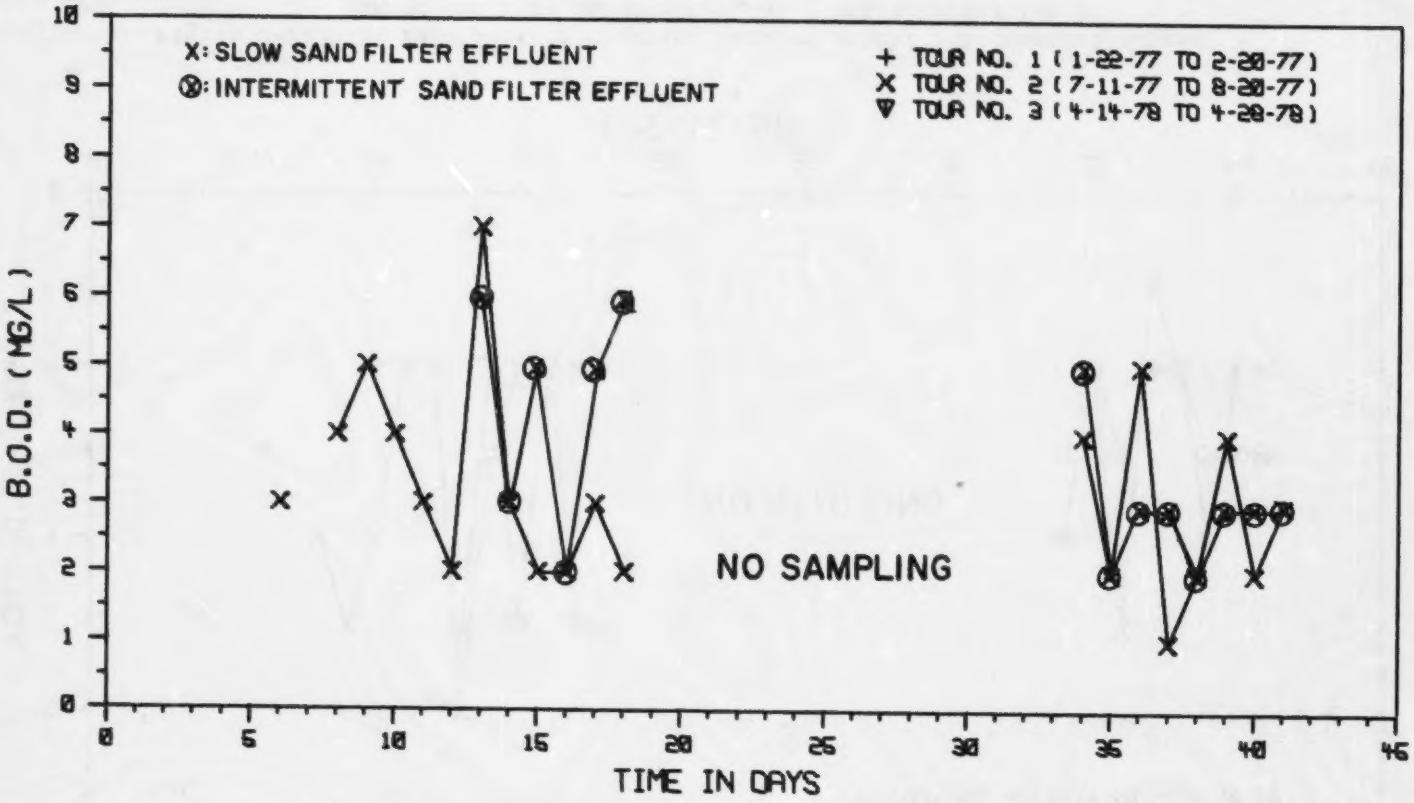


Figure B-1. The relationship observed between biochemical oxygen demand and time in days for the parallel operation of intermittent sand filters and slow sand filters during tour No. 2 at the Mount Shasta water pollution control facility.

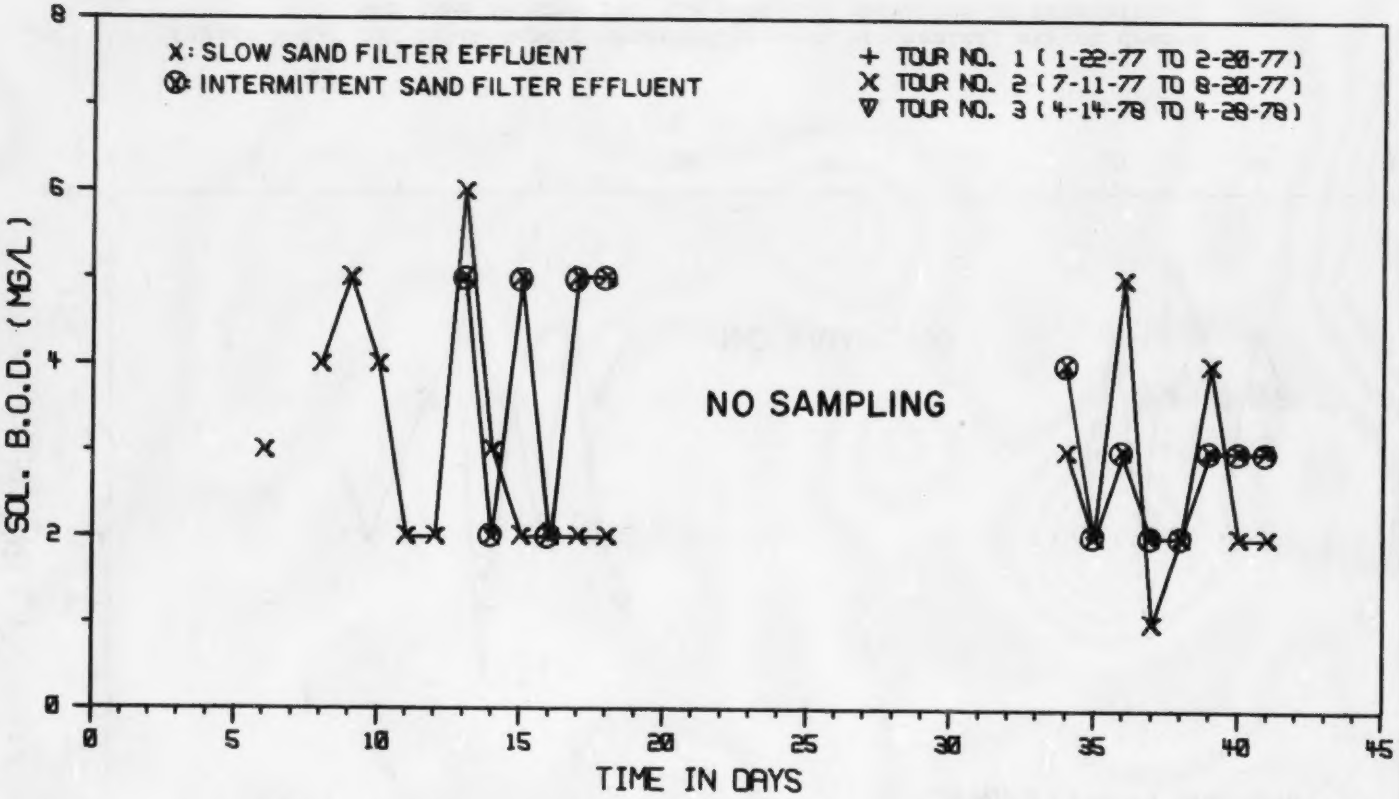


Figure B-2. The relationship observed between soluble biochemical oxygen demand and time in days for the parallel operation of intermittent sand filters and slow sand filters during tour No. 2 at the Mount Shasta water pollution control facility.

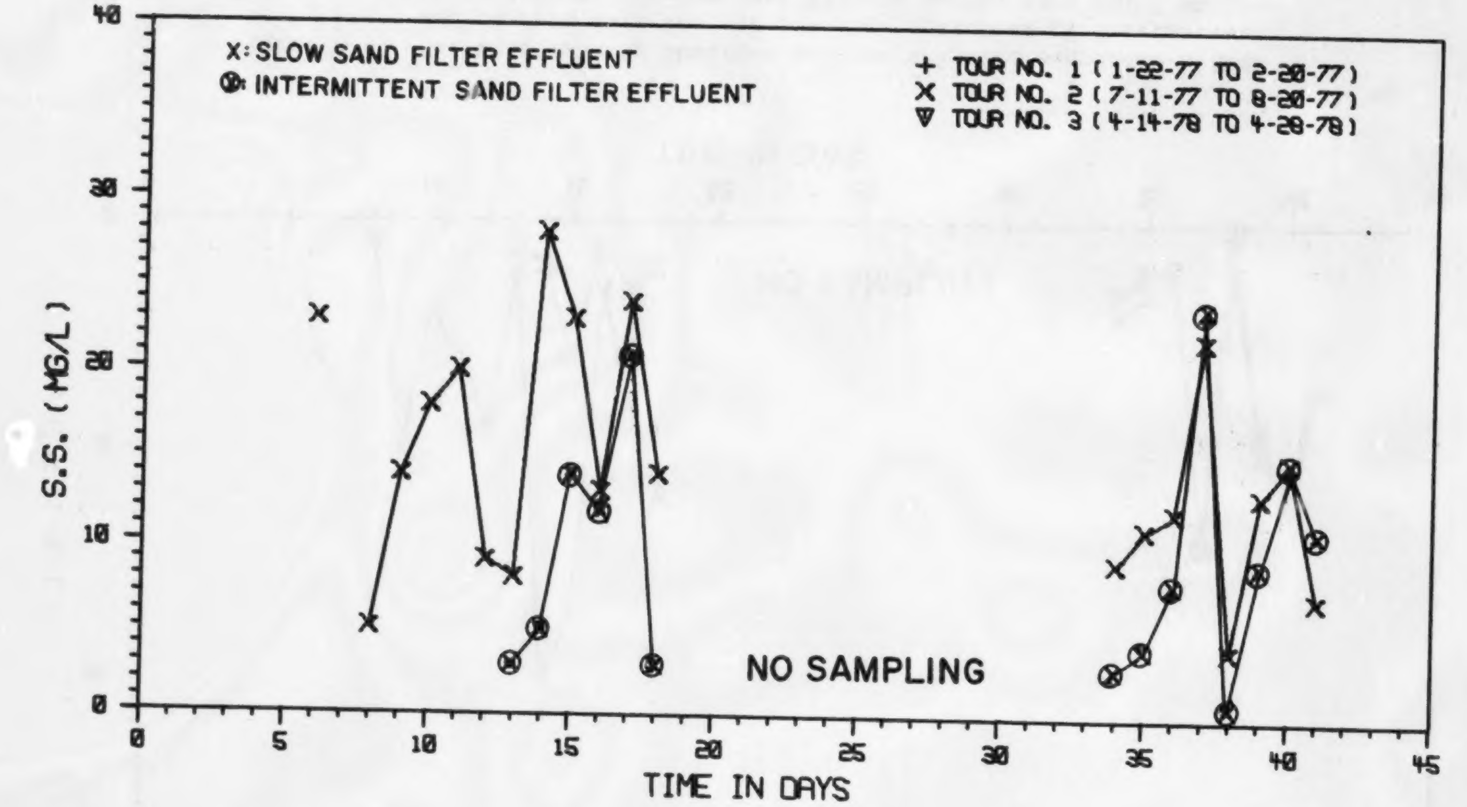


Figure B-3. The relationship observed between suspended solids and time in days for the parallel operation of intermittent sand filters and slow sand filters during tour No. 2 at the Mount Shasta water pollution control facility.

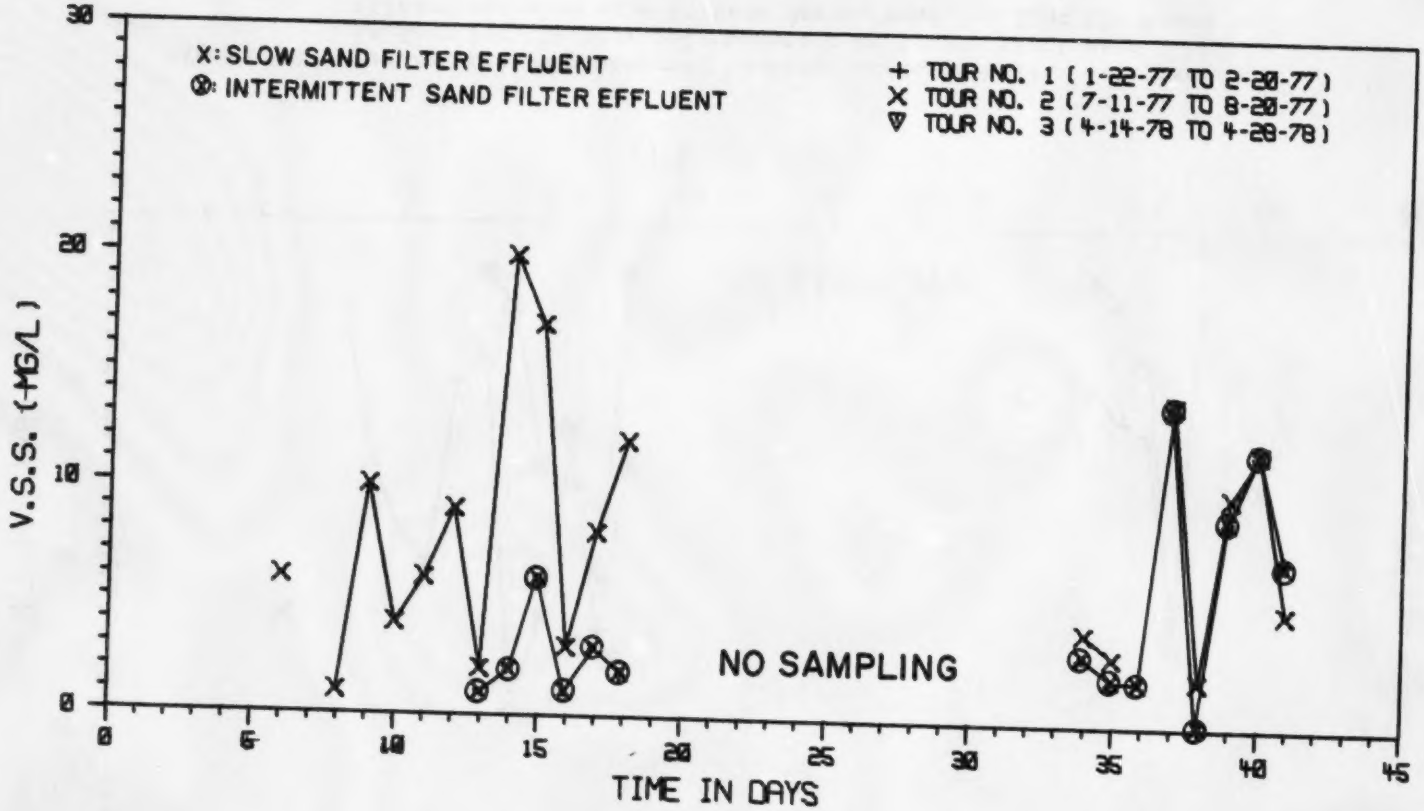


Figure B-4. The relationship observed between volatile suspended solids and time in days for the parallel operation of intermittent sand filters and slow sand filters during tour No. 2 at the Mount Shasta water pollution control facility.

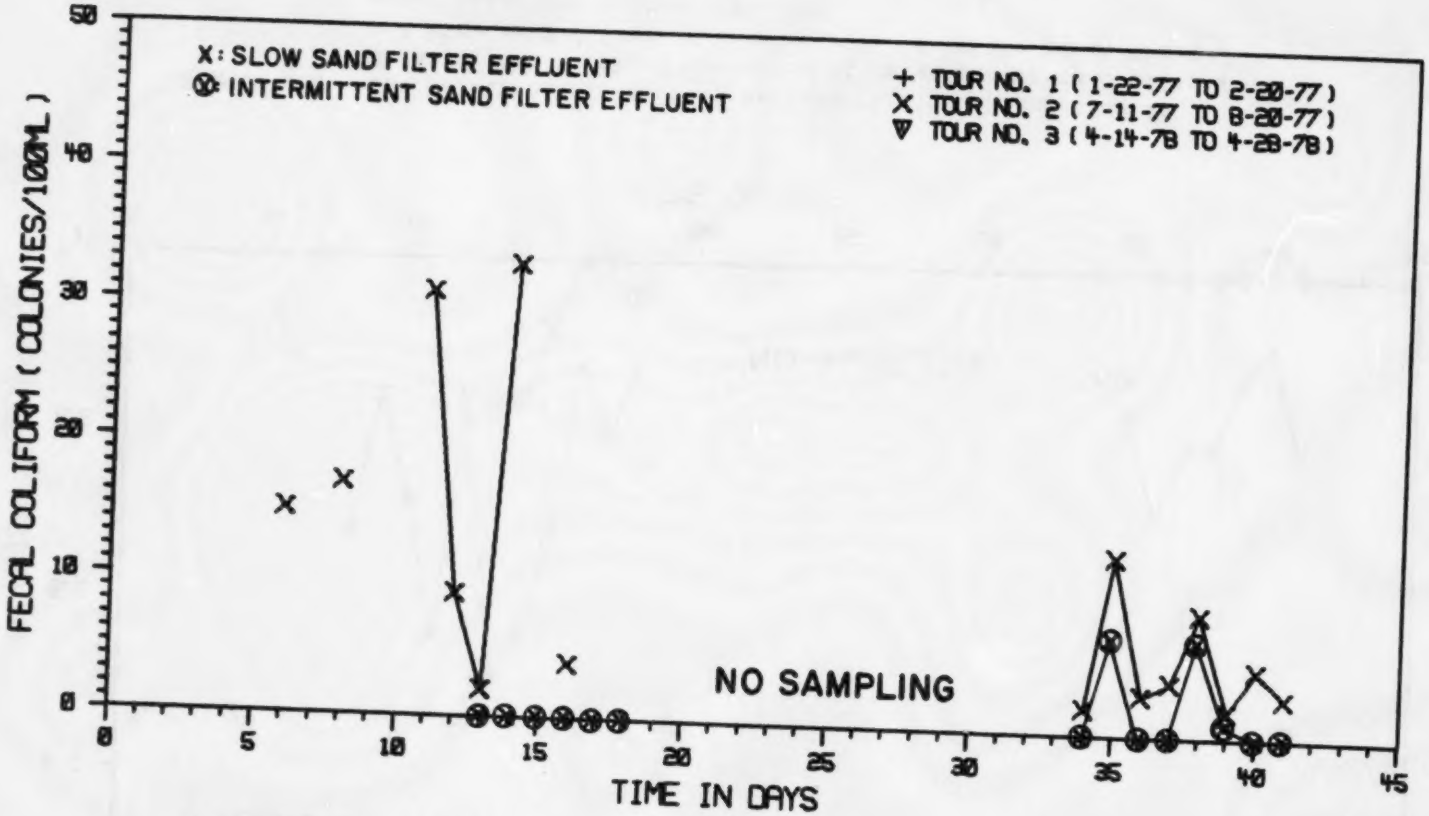


Figure B-5. The relationship observed between fecal coliform bacteria and time in days for the parallel operation of intermittent sand filters and slow sand filters during tour No. 2 at the Mount Shasta water pollution control facility.

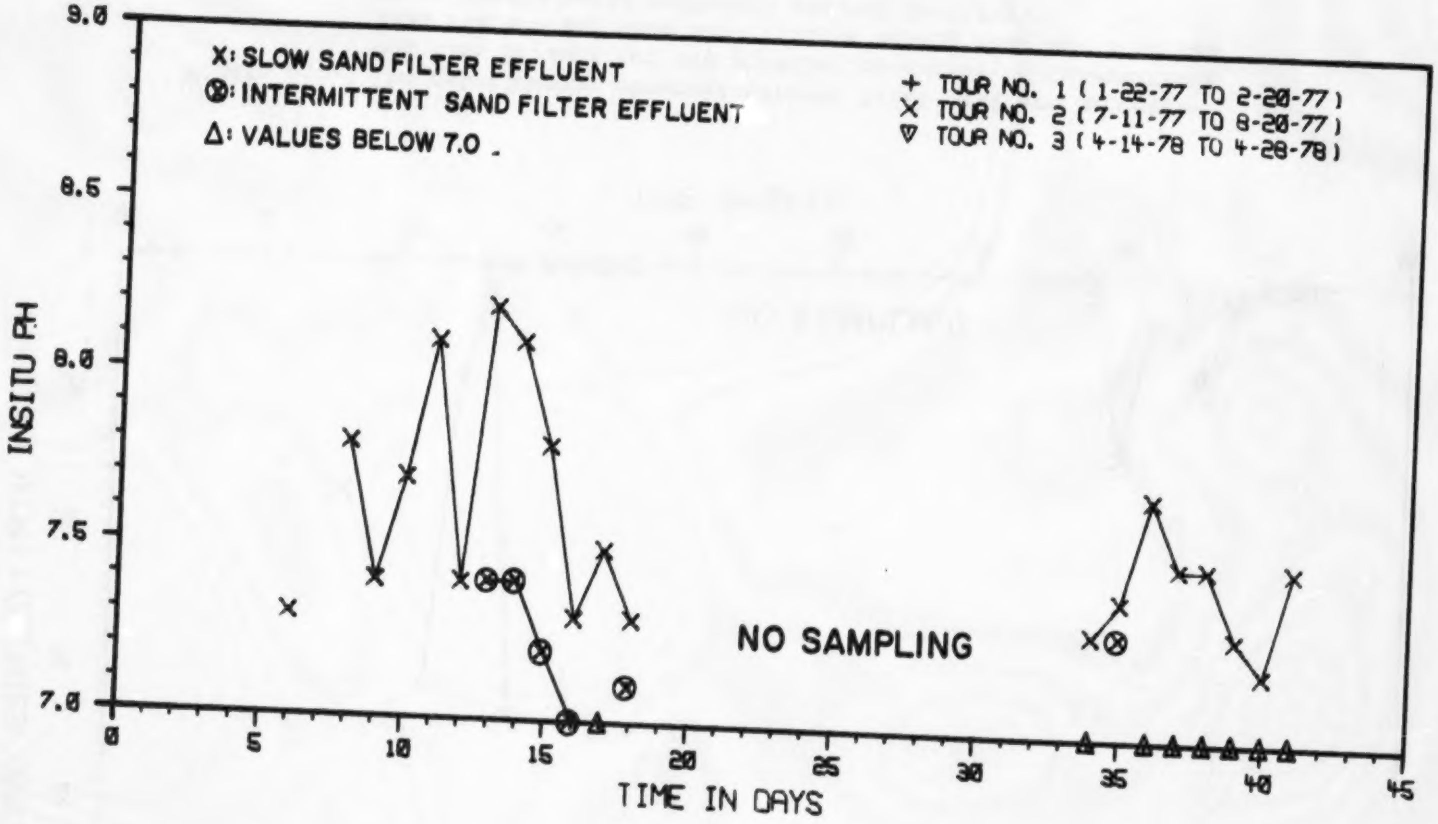


Figure B-6. The relationship observed between in situ pH and time in days for the parallel operation of intermittent sand filters and slow sand filters during tour No. 2 at the Mount Shasta water pollution control facility.

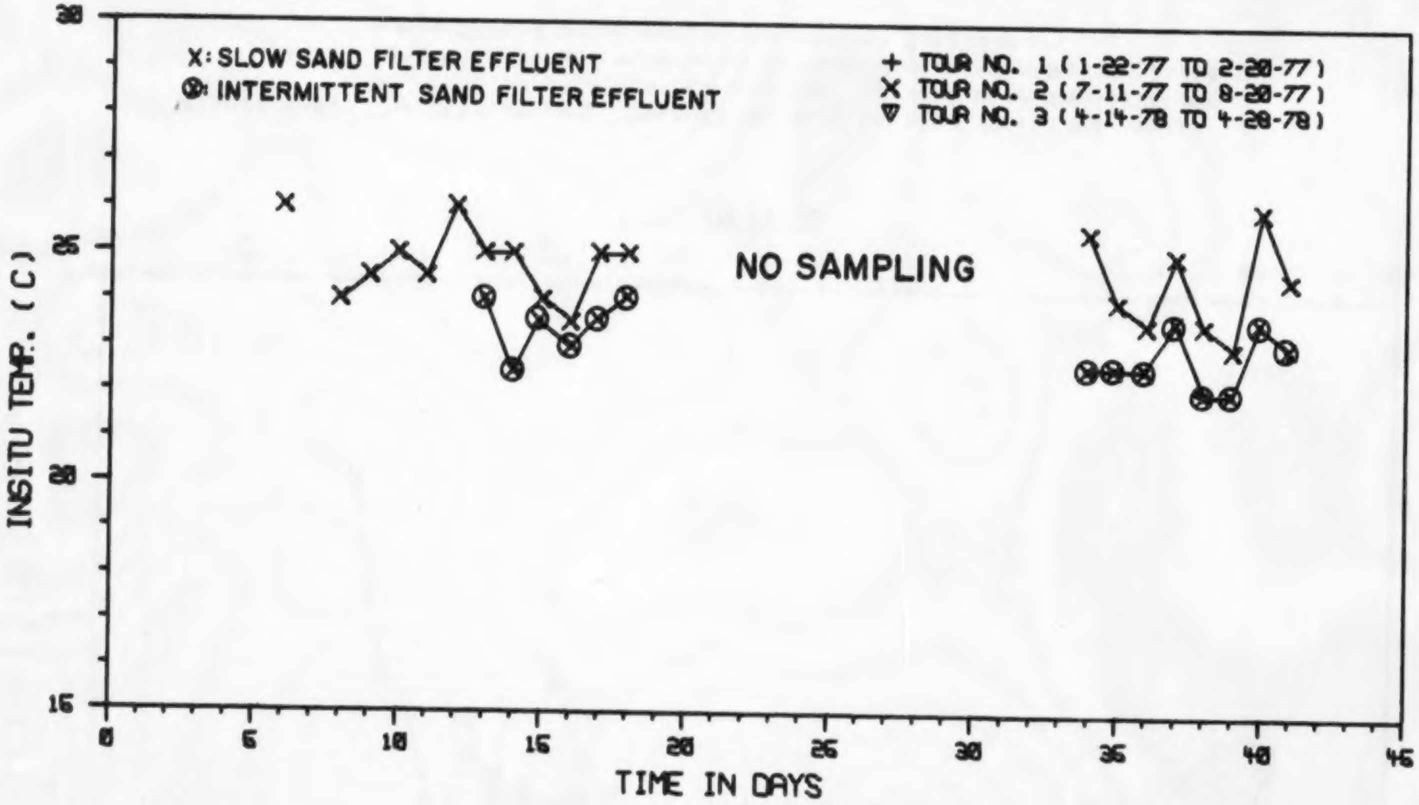
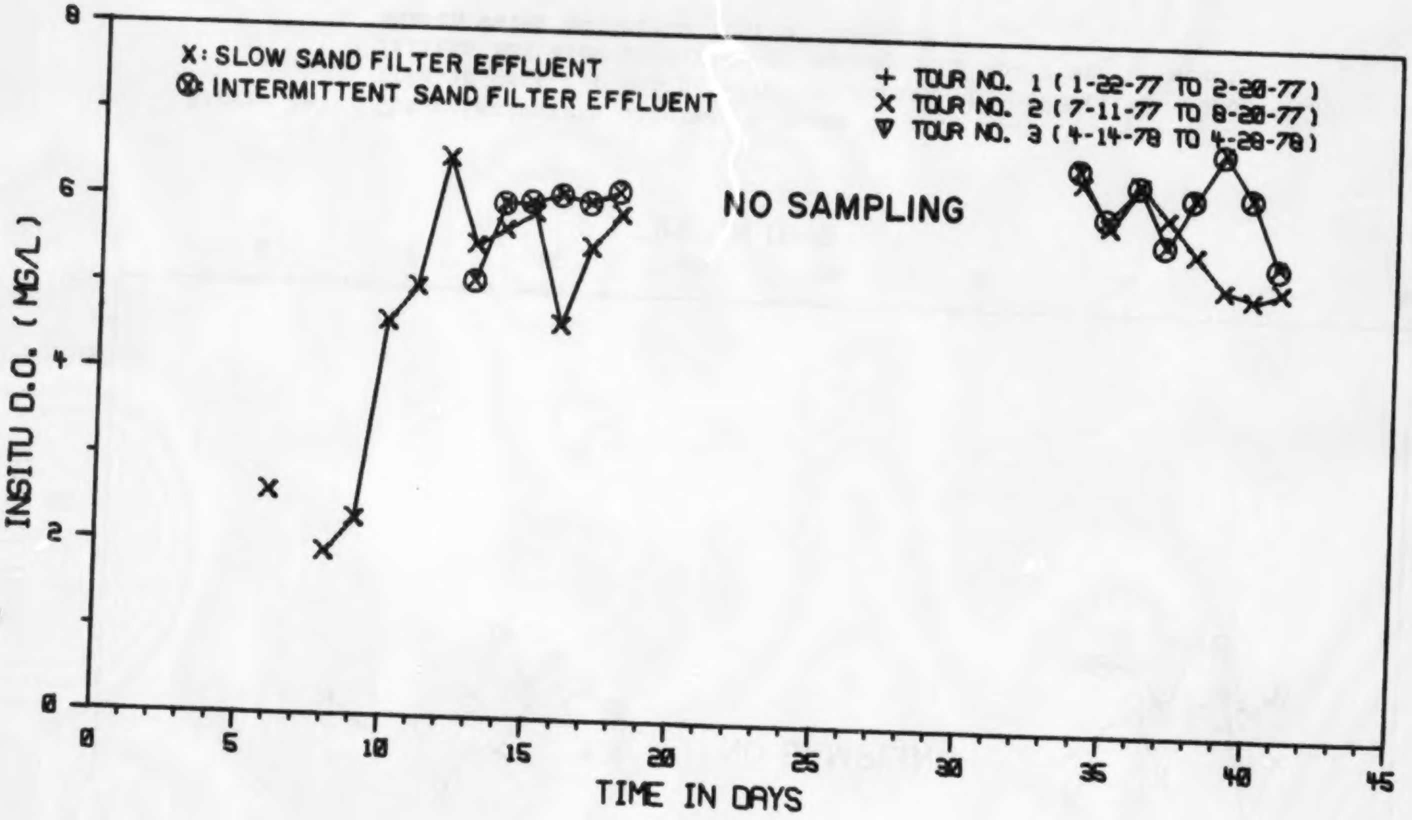


Figure B-7. The relationship observed between in situ temperature and time in days for the parallel operation of intermittent sand filters and slow sand filters during tour No. 2 at the Mount Shasta water pollution control facility.



'Figure B-8. The relationship observed between in situ dissolved oxygen and time in days for the parallel operation of intermittent sand filters and slow sand filters during tour No. 2 at the Mount Shasta water pollution control facility.

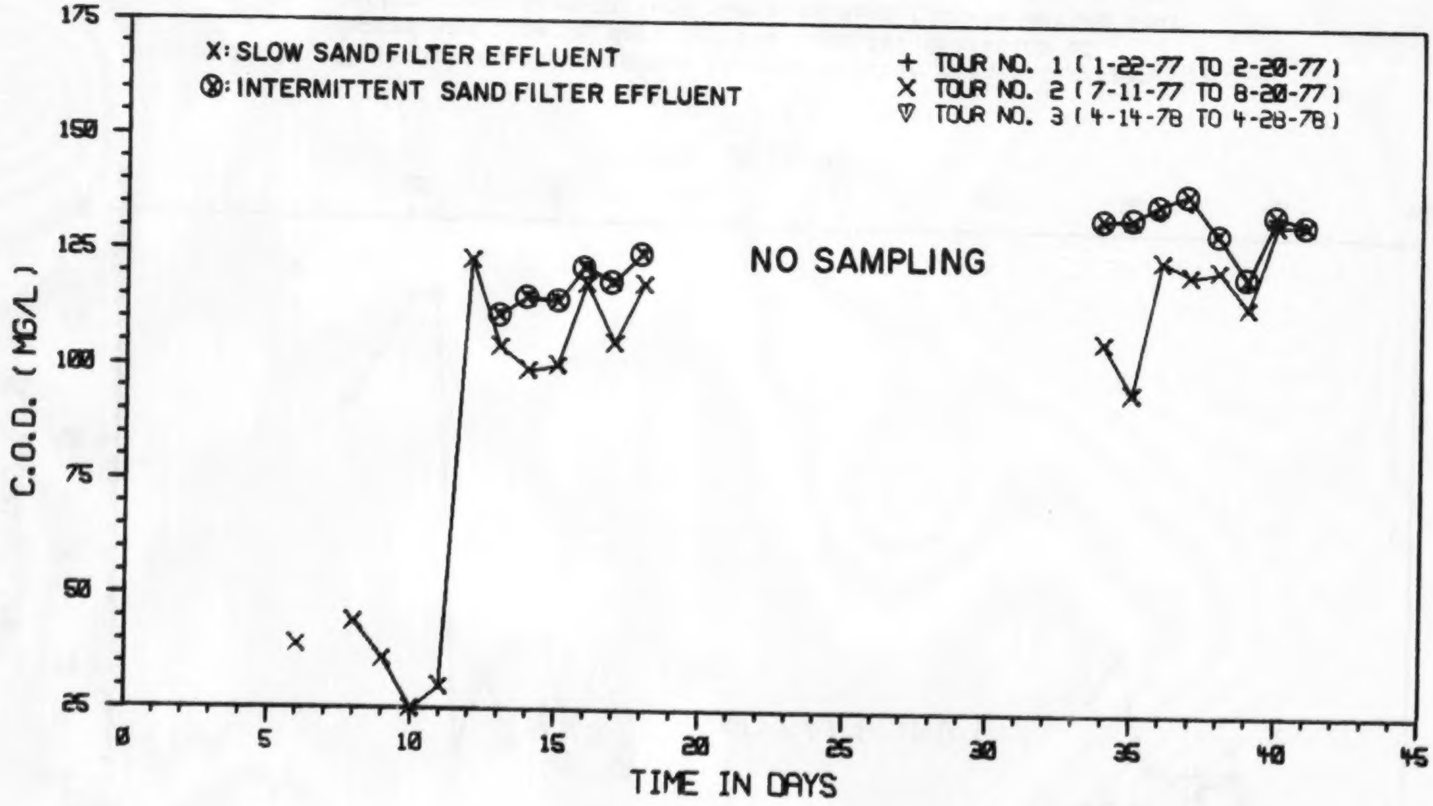


Figure B-9. The relationship observed between chemical oxygen demand and time in days for the parallel operation of intermittent sand filters and slow sand filters during tour No. 2 at the Mount Shasta water pollution control facility.

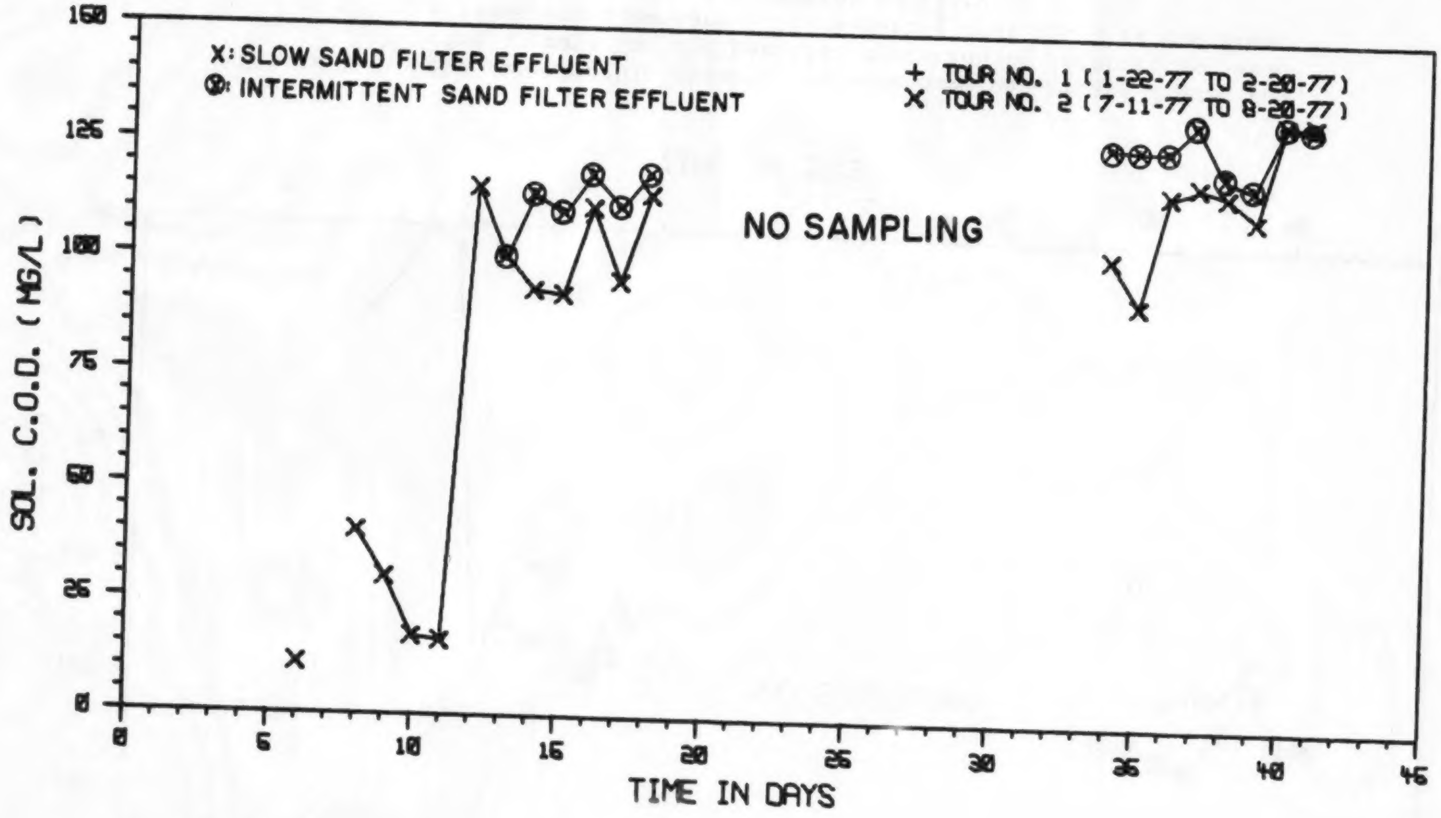


Figure B-10. The relationship observed between soluble chemical oxygen demand and time in days for the parallel operation of intermittent sand filters and slow sand filters during tour No. 2 at the Mount Shasta water pollution control facility.

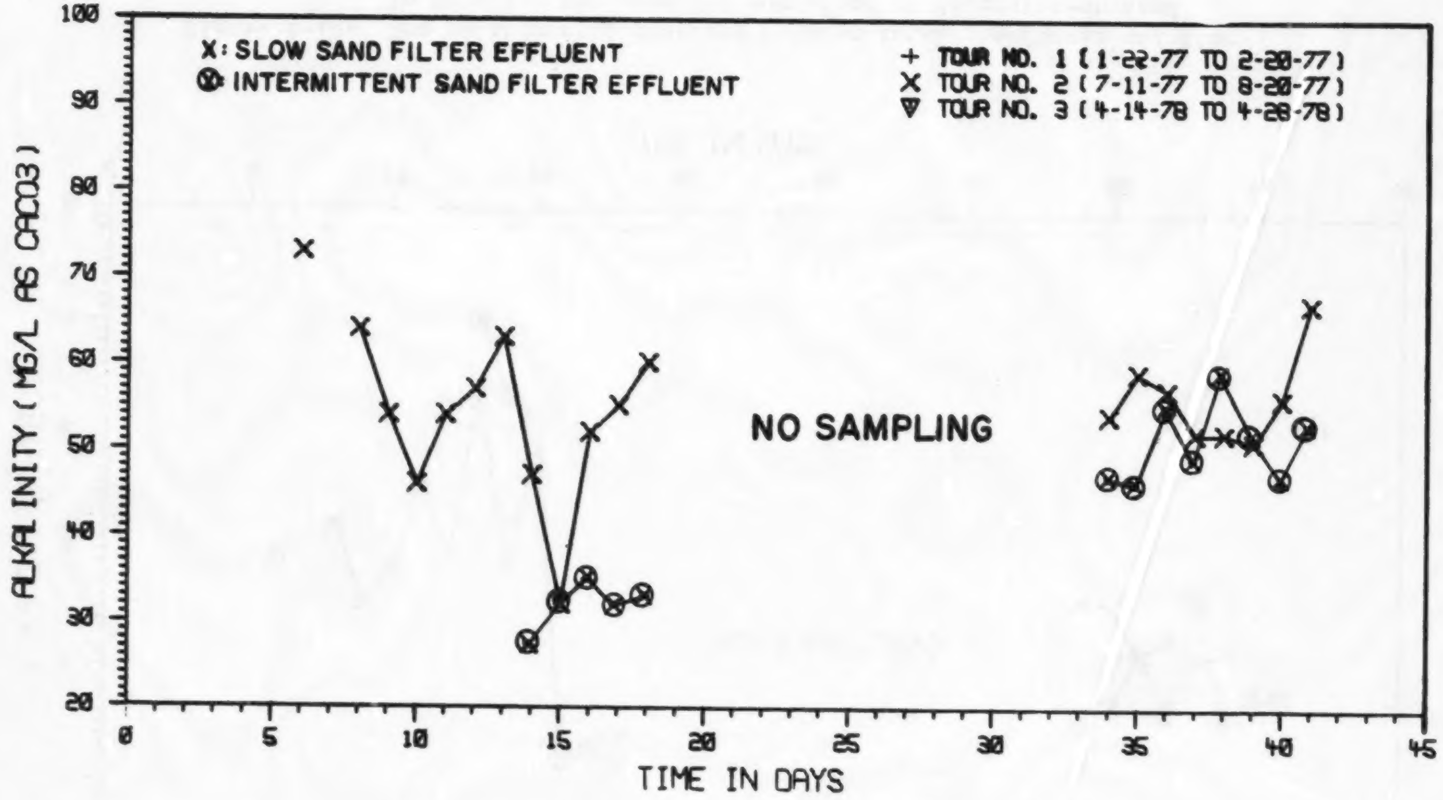


Figure B-11. The relationship observed between alkalinity and time in days for the parallel operation of intermittent sand filters and slow sand filters during tour No. 2 at the Mount Shasta water pollution control facility.

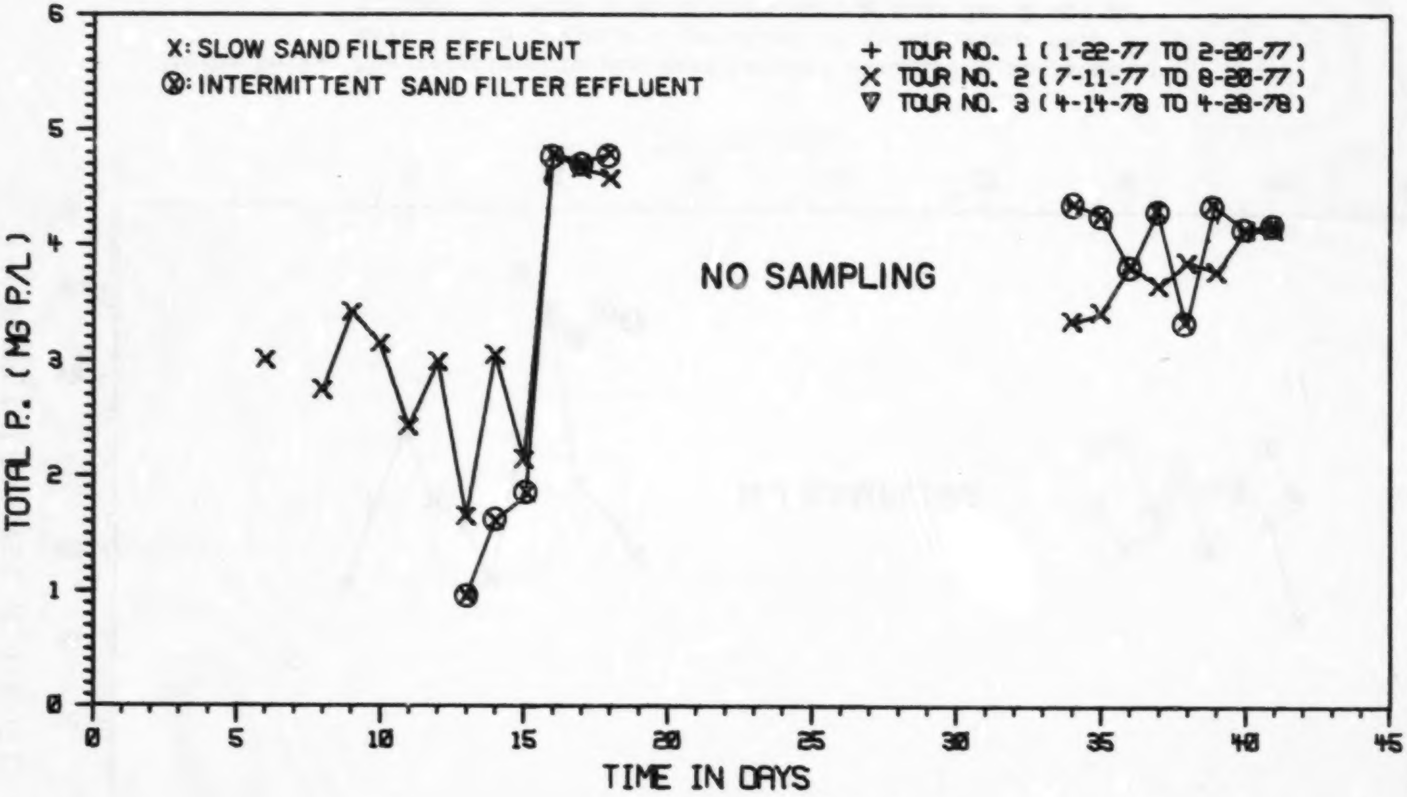


Figure B-12. The relationship observed between total phosphorus and time in days for the parallel operation of intermittent sand filters and slow sand filters during tour No. 2 at the Mount Shasta water pollution control facility.

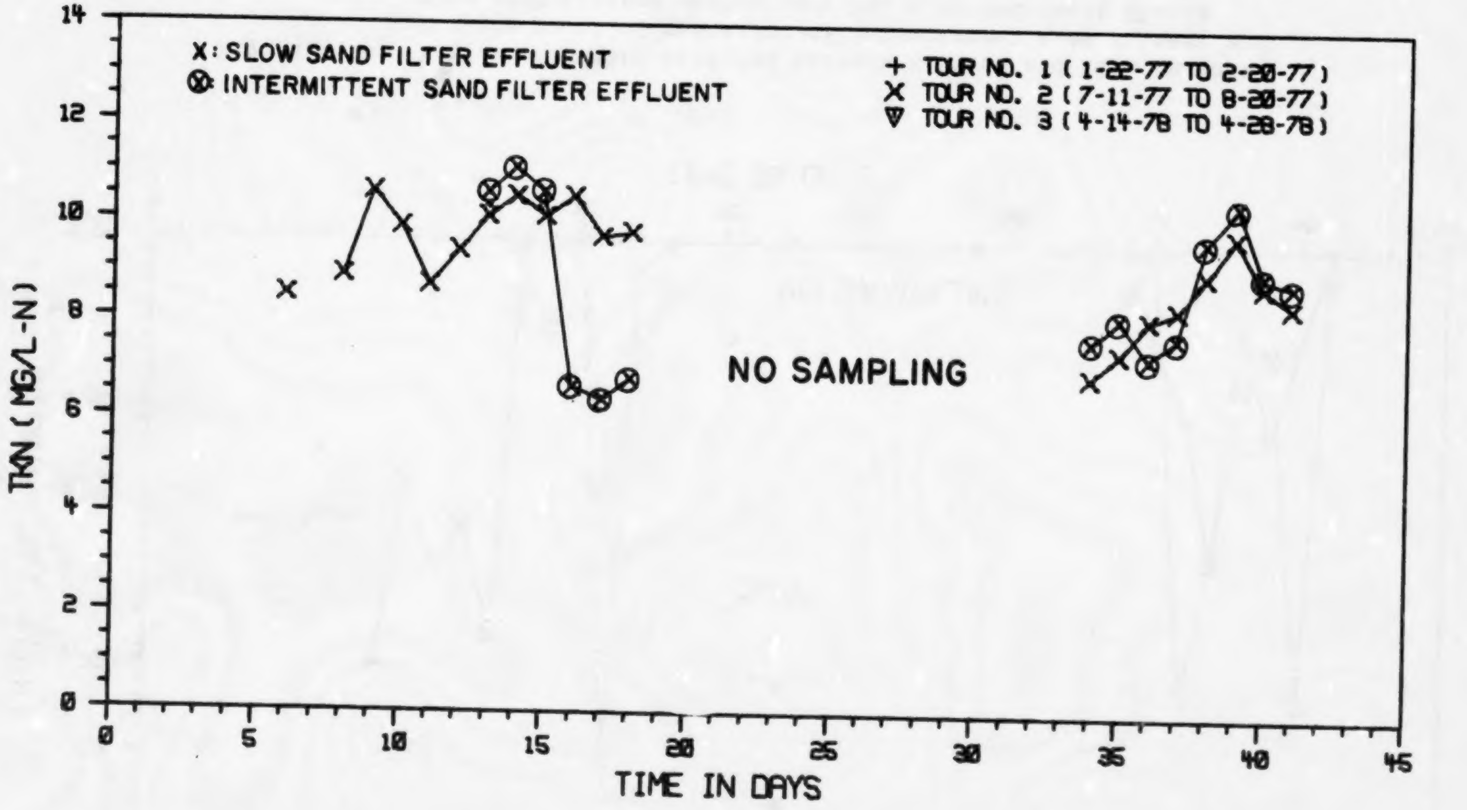


Figure B-13. The relationship observed between total kjeldahl nitrogen and time in days for the parallel operation of intermittent sand filters and slow sand filters during tour No. 2 at the Mount Shasta water pollution control facility.

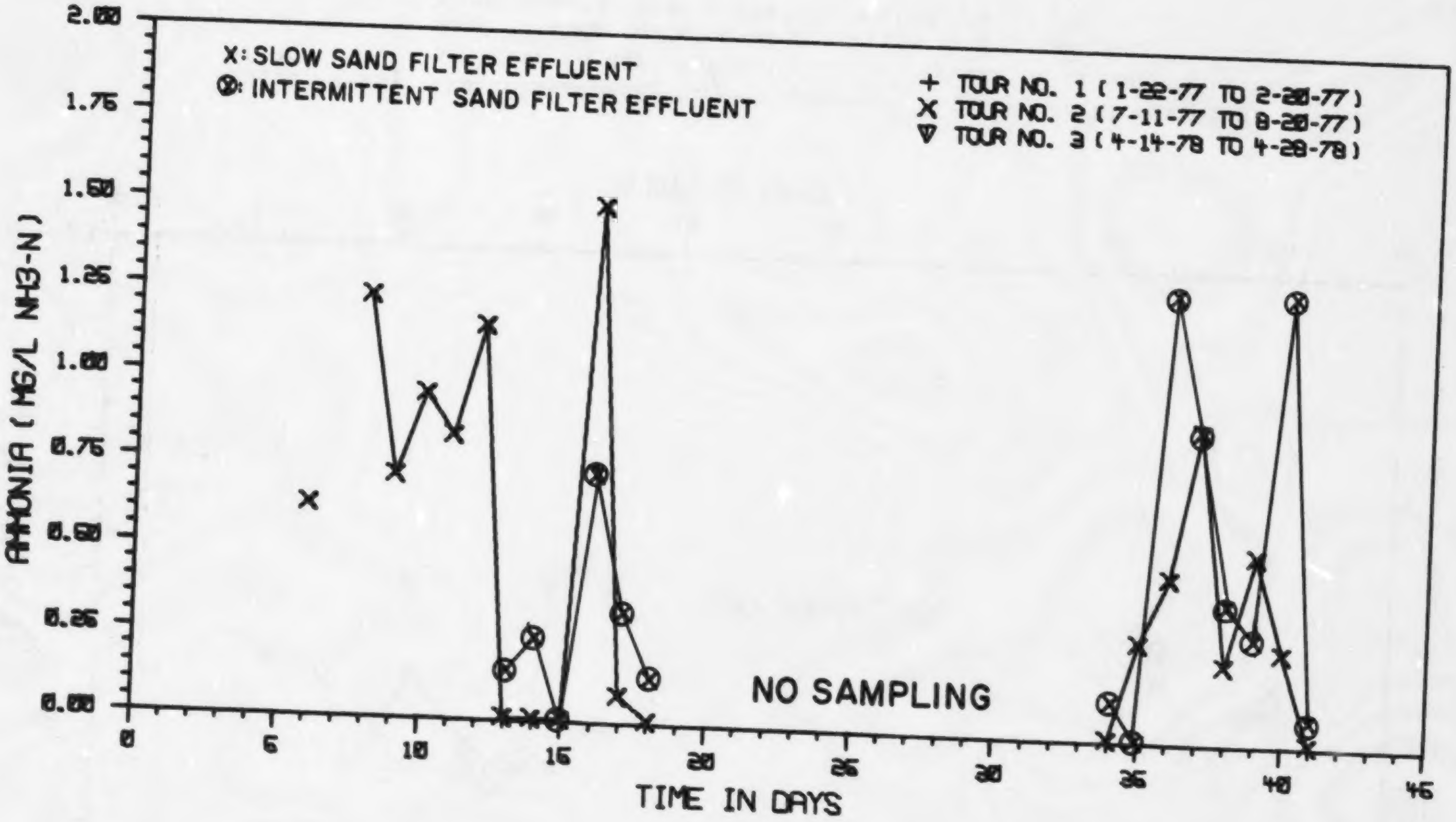


Figure B-14. The relationship observed between ammonia and time in days for the parallel operation of intermittent sand filters and slow sand filters during tour No. 2 at the Mount Shasta water pollution control facility.

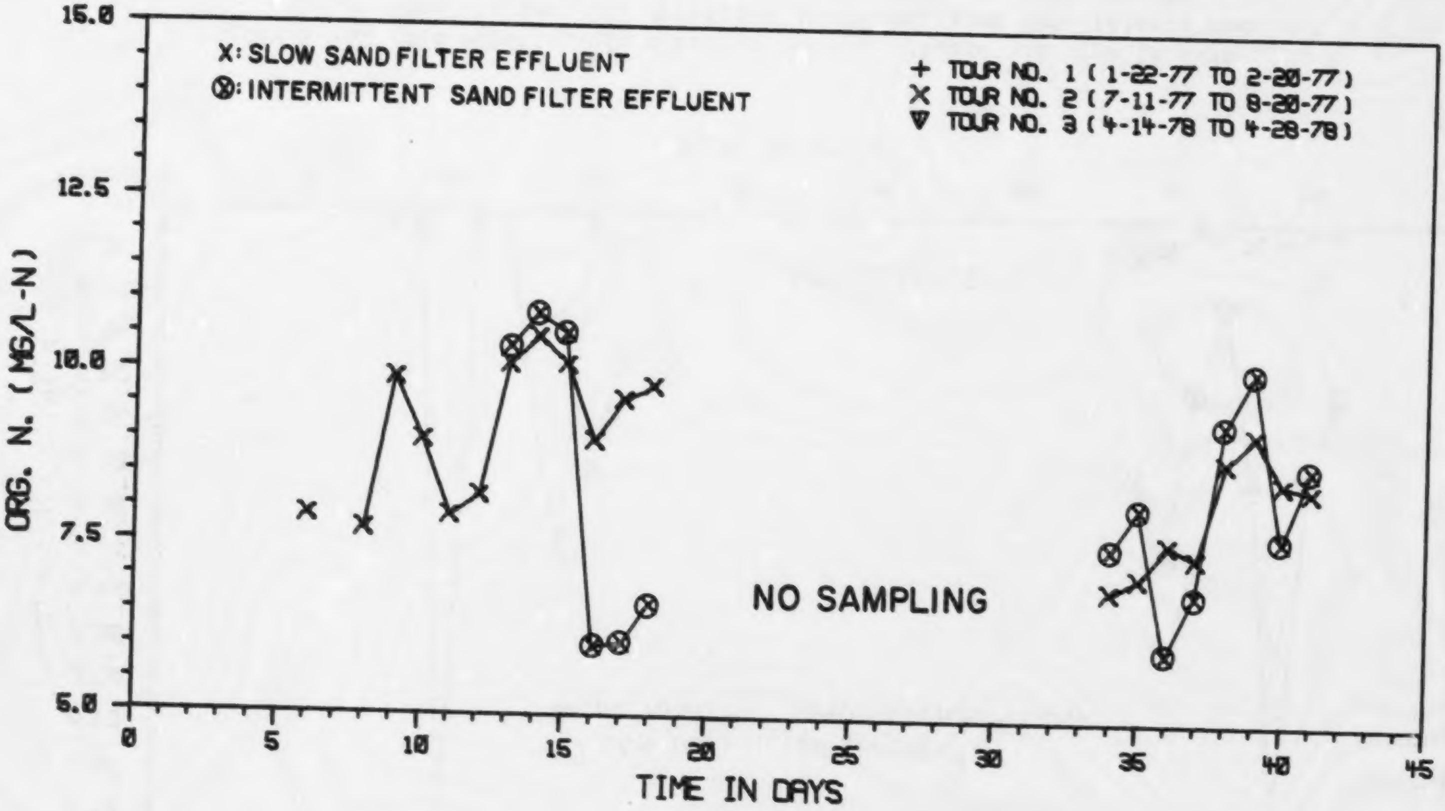


Figure B-15. The relationship observed between organic nitrogen and time in days for the parallel operation of intermittent sand filters and slow sand filters during tour No. 2 at the Mount Shasta water pollution control facility.

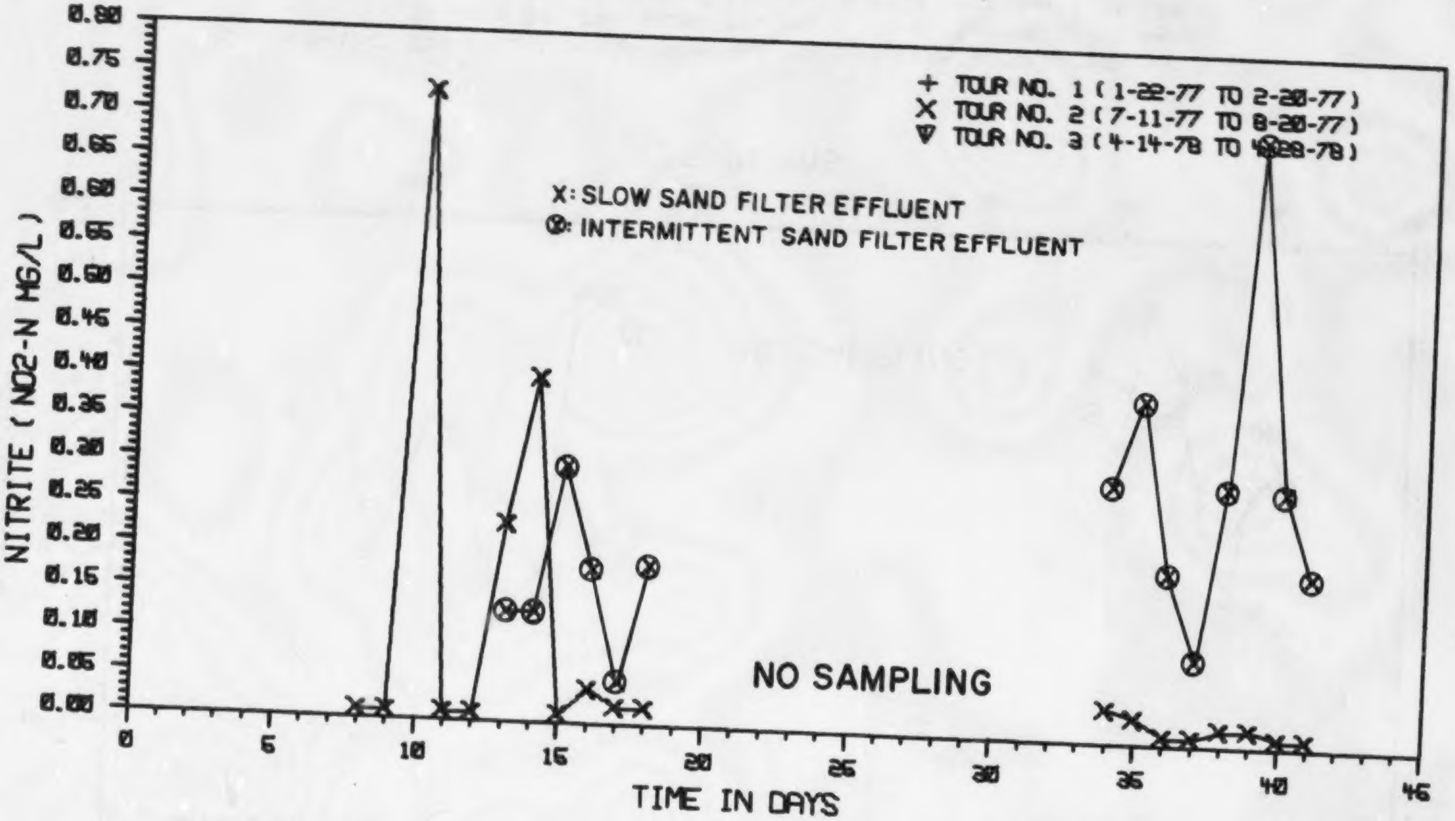


Figure B-16. The relationship observed between nitrite and time in days for the parallel operation of intermittent sand filters and slow sand filters during tour No. 2 at the Mount Shasta water pollution control facility.

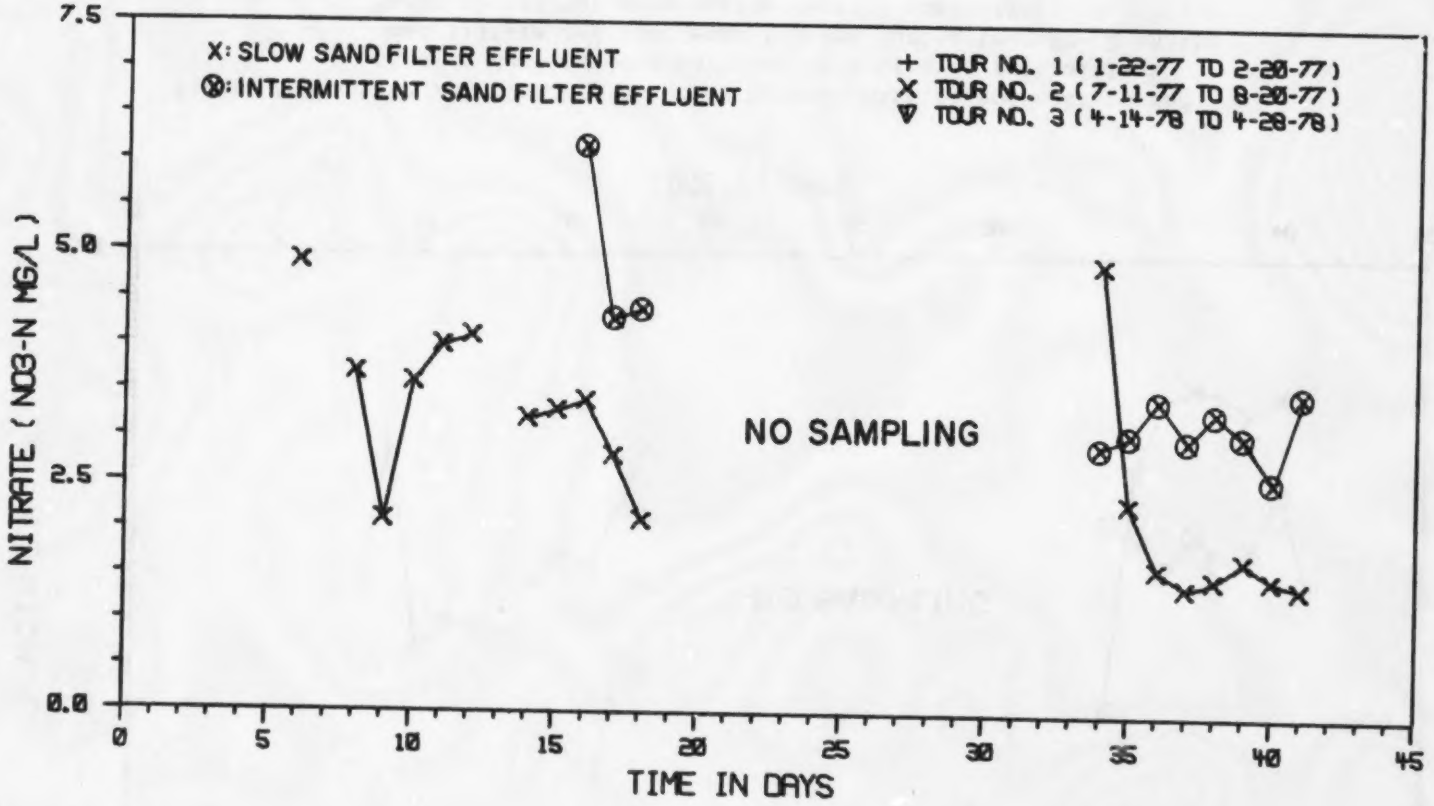


Figure B-17. The relationship observed between nitrate and time in days for the parallel operation of intermittent sand filters and slow sand filters during tour No. 2 at the Mount Shasta water pollution control facility.

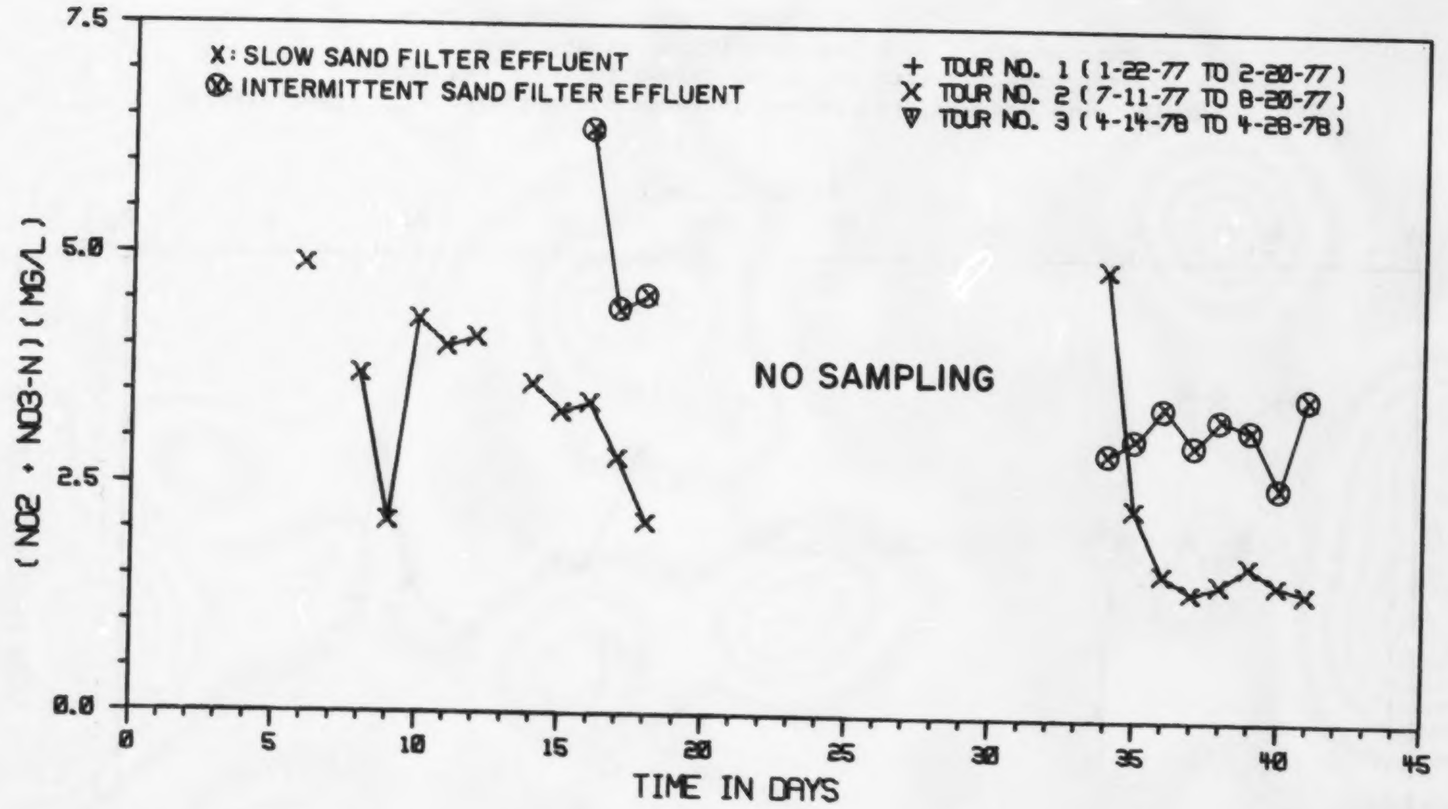


Figure B-18. The relationship observed between nitrite and nitrate and time in days for the parallel operation of intermittent sand filters and slow sand filters during tour No. 2 at the Mount Shasta water pollution control facility.

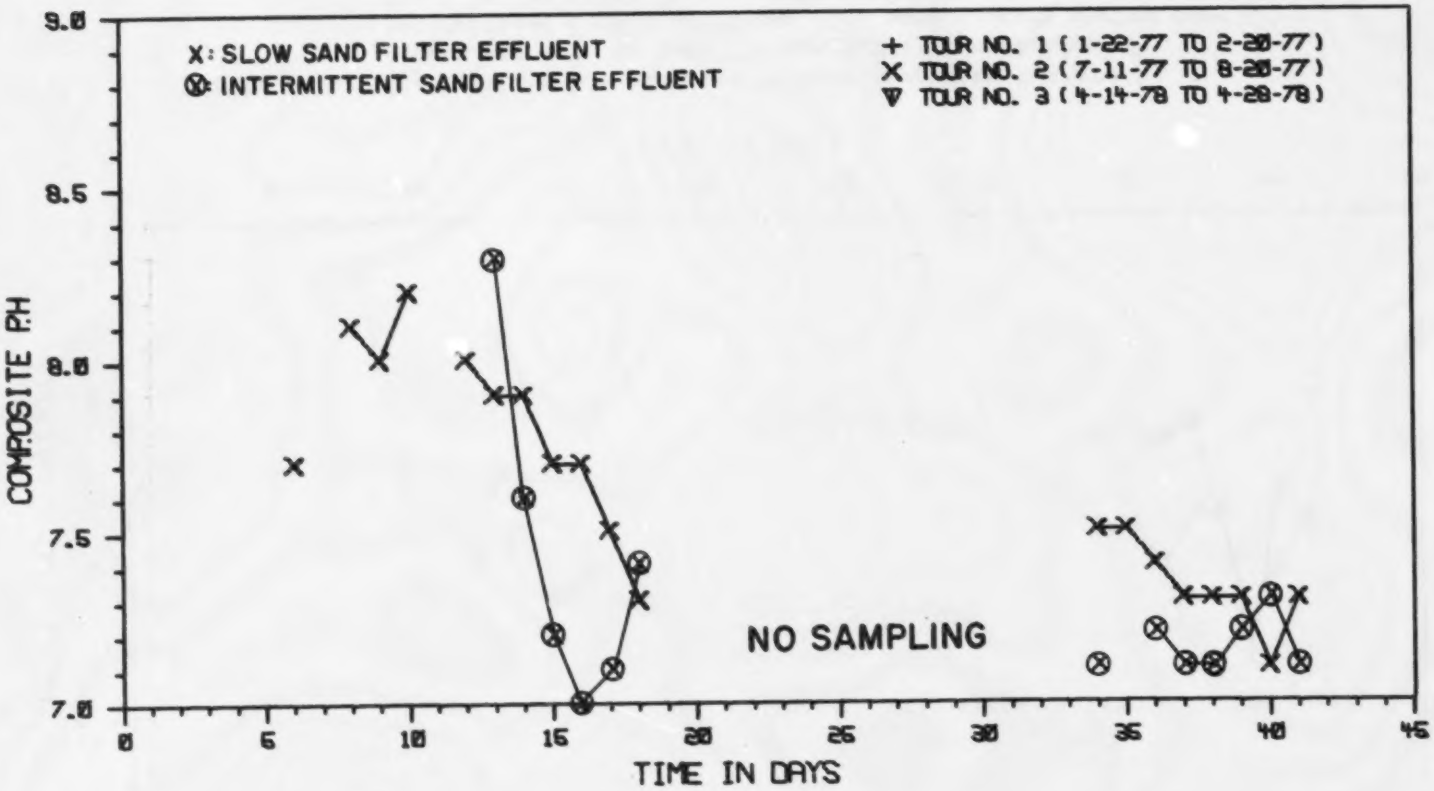


Figure B-19. The relationship observed between composite pH and time in days for the parallel operation of intermittent sand filters and slow sand filters during tour No. 2 at the Mount Shasta water pollution control facility.

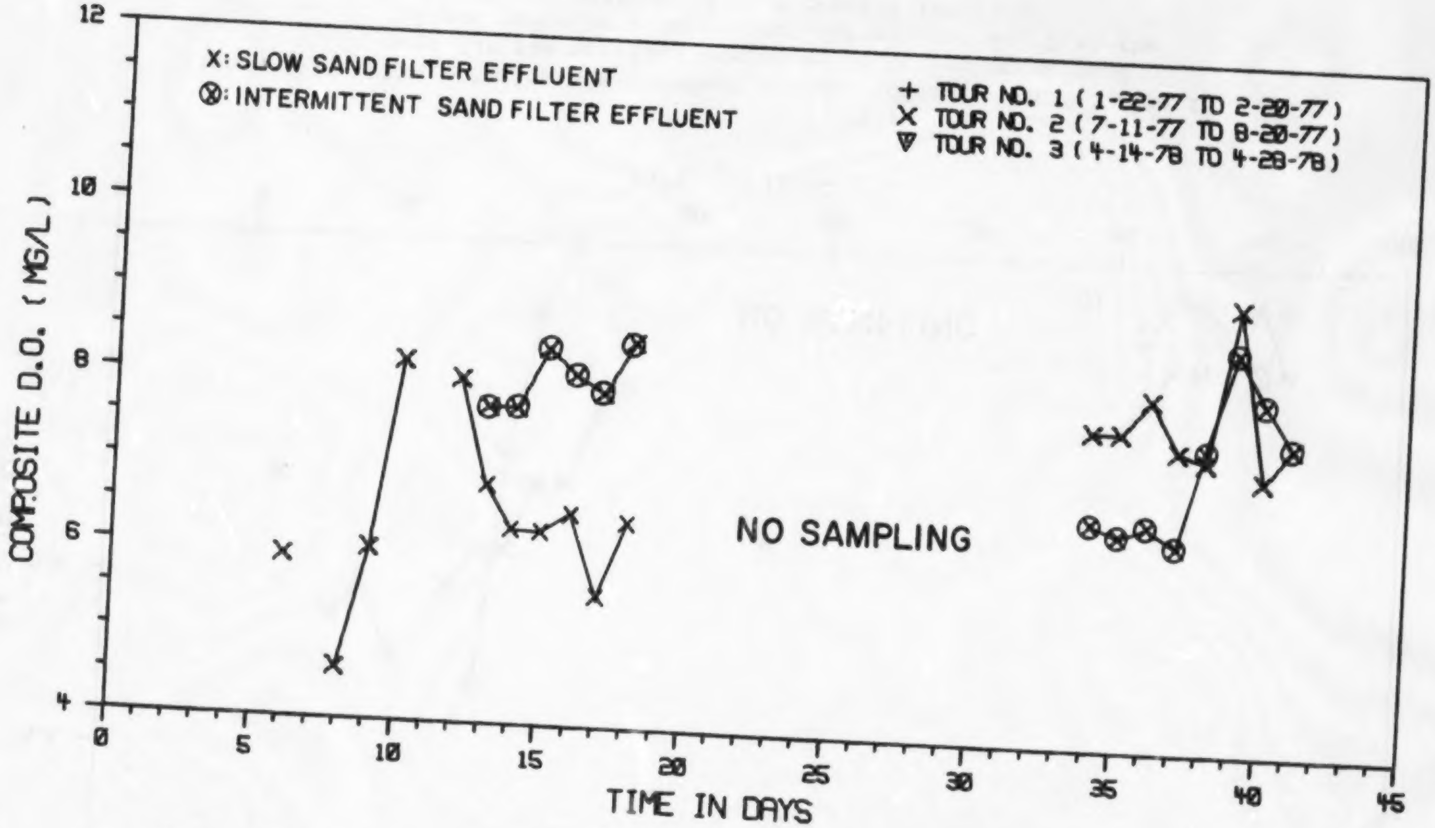


Figure B-20. The relationship observed between composite dissolved oxygen and time in days for the parallel operation of intermittent sand filters and slow sand filters during tour No. 2 at the Mount Shasta water pollution control facility.

APPENDIX C

TYPICAL DESIGN OF AN INTERMITTENT SAND FILTER

Known Parameters

Design Flowrate = (100,000 GPD) 378 m^3/d

Assumptions

1) Designed to minimize O & M
2) Gravity flow
3) Topography and location satisfactory
4) Adequate land available at reasonable cost
5) Filter sand is locally available
6) Filters are considered plugged when at the time of dosing the water from the previous dose has not dropped below the filter surface

Loading Rates and Number of Filters Required

Hydraulic loading rate = 2806 $m^3/ha \cdot d$ (0.30 MGAD)
Minimum number of filters = 2

$$\text{Area of Filters} = \frac{\text{design flow}}{\text{HLR}} = \frac{378\ m^3/d}{2806\ m^3/ha \cdot d} = 0.135\ \text{hectare}\ (0.33\ \text{acre})$$

Area of each filter unit should be 0.135 ha. Use 2 filters

Area required/filter = 0.135 ha = 1,350 m^2

Dimensions of Filters

$\text{Area} = L \times W$

using rectangular dimensions and letting $L = 2W$

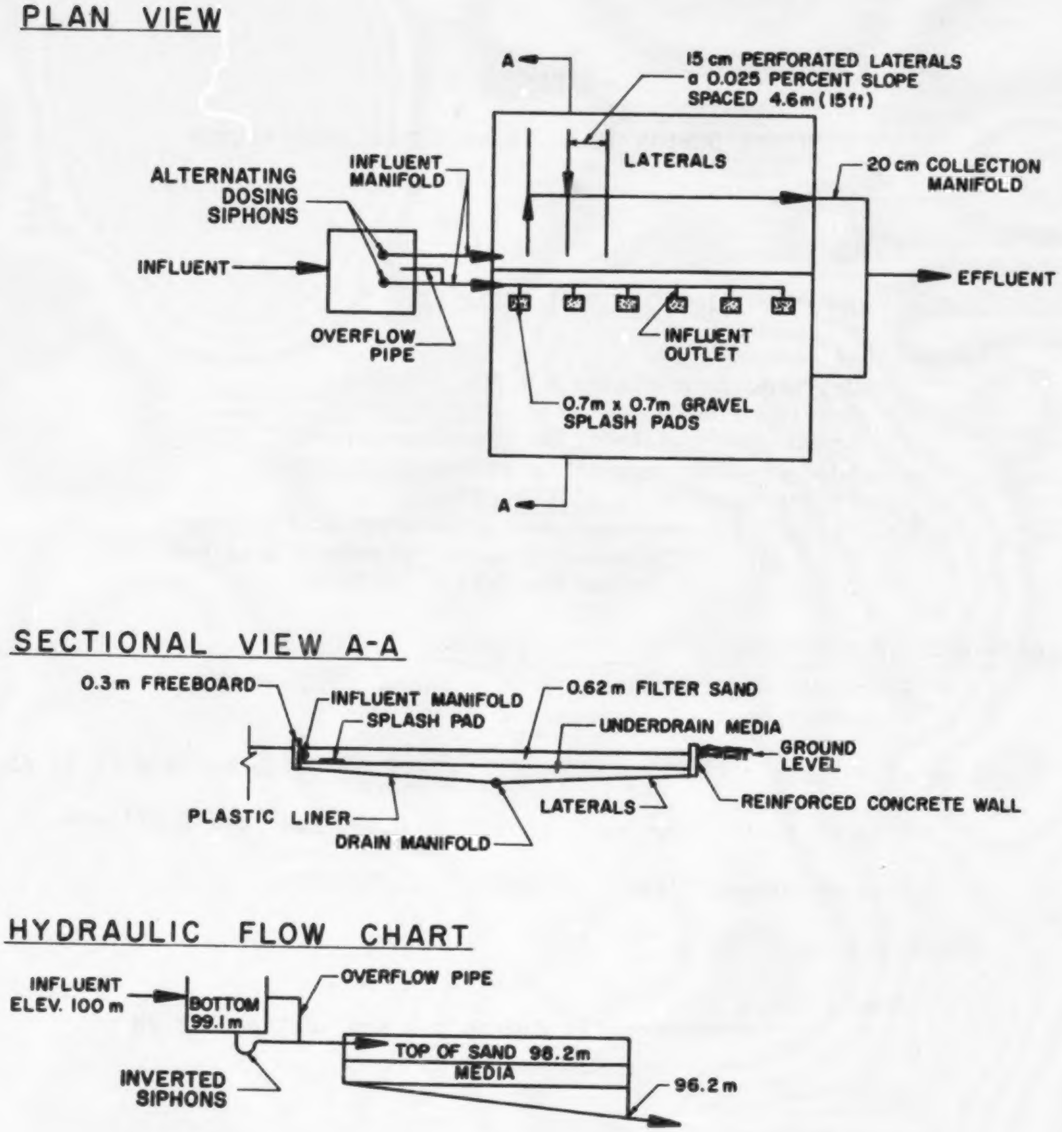
$\text{Area} = 2W^2$

$W = \sqrt{\text{area}/2}$

$W = \sqrt{1,350/2} = 26.0\ m$

$L = 2W = 2(26.0) = 52.0\ m$

Construct two filters 26.0 m × 52.0 m (85.3 ft × 170.6 ft) side by side as shown in Figure C-1.



PLAN VIEW

SECTIONAL VIEW A-A

HYDRAULIC FLOW CHART

A
15 cm PERFORATED LATERALS
a 0.025 PERCENT SLOPE
SPACED 4.6m (15ft)
LATERALS
20 cm COLLECTION MANIFOLD
ALTERNATING DOSING SIPHONS
INFLUENT MANIFOLD
INFLUENT
EFFLUENT
OVERFLOW PIPE
INFLUENT OUTLET
0.7m x 0.7m GRAVEL SPLASH PADS
A
0.3m FREEBOARD
INFLUENT MANIFOLD
SPLASH PAD
0.62m FILTER SAND
UNDERDRAIN MEDIA
GROUND LEVEL
PLASTIC LINER
LATERALS
REINFORCED CONCRETE WALL
DRAIN MANIFOLD
INFLUENT ELEV. 100 m
BOTTOM 99.1m
OVERFLOW PIPE
TOP OF SAND 98.2m
MEDIA
INVERTED SIPHONS
96.2m

Figure C-1. Typical intermittent sand filter design.

Influent Distribution System

Intermittent Filter Loading System

Assumptions

1) Use a dosing basin with gravity feed to the filters.
2) Loading sequence will deliver one half the daily flowrate to each filter unit per day in two equal doses.
3) Loading system will consist of two electrically activated valves that are operated alternately by a simple electronic control system triggered by a float switch or two alternating dosing siphons.
4. Pipe sizes are selected to avoid clogging and to make cleaning convenient. Hydraulics do not control.

Dosing Basin Size

Use two equal dosings per day per filter. Provides option of operating filters in parallel or individually.

Design Flow Rate = 378 m^3/d

$$\text{Flow to Each Filter Unit} = \frac{378\ m^3/d}{2\ \text{filters}} = 189\ m^3/d$$

$$\text{Volume applied in two equal doses per filter unit per day} = \frac{189\ m^3/d}{2\ \text{dosing/day}}$$

Dosing Basin Volume = 94.5 m^3/d

Use a square shape and a water depth of 0.92 m (3 ft) to minimize velocity in distribution system. Use 0.3 m (1 ft) free board and install overflow pipe. Total depth = 1.22 m (4 ft).

$$\text{Area} = \frac{\text{volume}}{\text{depth}} = \frac{94.5\ m^3}{0.92\ m} = 102.7\ m^2$$

$$\text{Width} = \sqrt{102.7\ m^2} = 10.2\ m$$

Dosing Basin Size = 10.2 m square × 1.22 m deep

Distribution manifold from the two valves leading to the individual filters would be 20 cm dia. pipe. Each of the outlets from the manifold will serve 6.1 m of the long side of the filter unit. The manifold outlets will discharge onto splash pads constructed of large gravel (7.5 cm to 3.8 cm avg. dia.) placed in a 0.7 m square configuration at each outlet opening.

Filter Containment and Filter Underdrain (see Figure 95)

Use a reinforced concrete retaining structure or a 20 mil plastic liner to prevent infiltration and exfiltration to adjacent ground water.

Slopes of filter bottom are dependent on drain pipe configuration using 0.025 percent slope with lateral collection lines 4.6 m on center.

Utilization of 15 cm diameter perforated PVC pipe as collecting laterals and 20 cm diameter collection manifolds will provide adequate hydraulic capacity and ease of maintenance.

Minimum Freeboard required

Filter unit surface area = 1,350 m^2
Volume of water per dose = 94.5 m^3
Depth @ plugged condition with no immediate outflow

$$\text{Depth} = \frac{\text{volume}}{\text{area}} = \frac{94.5\ m^3}{1{,}350\ m^2} = 0.07\ m$$

Minimum freeboard required to accommodate wastewater when filter is plugged at time of application of the dose is 0.07 meters. However, with infrequent inspection by an operator it is recommended that a safety factor be specified and the value of 0.3 meters mentioned above be used.